AN INVESTIGATION OF CONTENT AND MASTERY OF HIGH SCHOOL GENERAL SCIENCE COURSES

by

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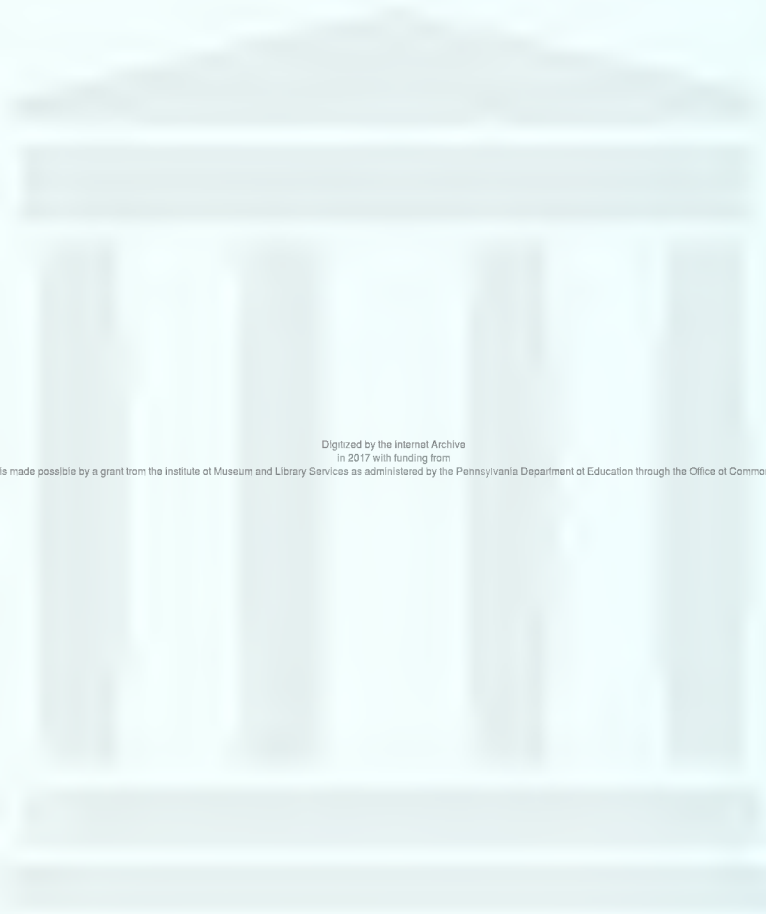
E. D. H.



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CHAPTER I

THE PROBLEM AND ITS HISTORICAL BACKGROUND

FIELD AND SCOPE OF STUDY

The investigations reported in this monograph come within the field known as general science. General science during the early period of its development was primarily a ninth grade subject in the four year high school. Lately there has been a tendency to require it of pupils in the seventh and eighth grades of the junior high school. The studies reported here, however, are confined, in the main, to the status of general science as a ninth grade subject.

The study is differentiated into three main problems:

1. To discover the basic instructional material now used in general science courses; i. e., to ascertain the basic facts, principles, and applications of science around which the courses are built.
2. To determine the extent of mastery of the basic instructional material of general science.
3. To study the relation of intelligence to achievement in general science.

THE GENERAL SCIENCE MOVEMENT

Science has always occupied a significant place in high school curricula. At the Boston English Classical School (established in 1821), generally regarded as the pioneer of the high school movement.

Natural Philosophy including Astronomy was prescribed for the last year. Later courses in chemistry, botany, zoology, geology, physiology, and biology appeared.

The development of these separate science courses took place during the time when the high schools were, for the most part, under the domination of colleges and universities. As a result the high school science courses became to a considerable degree diluted and denatured college courses. These courses in addition to being founded upon the false notion of mental discipline were looked upon essentially as preparatory work for college.

But during the latter part of the nineteenth and beginning of the twentieth centuries rapid changes in school population made fresh demands on the schools which the old science courses could not adequately meet. Great economic changes were taking place in this country as a result of the rapid progress made in the fields of science and invention. More children were able to secure the benefits of a high school education and the enrollment in secondary schools increased by leaps and bounds.

The great majority of these children were not preparing for college, however, so that they found the college preparatory type of science instruction rather dull and for the most part unsuited to their tastes. The reports of the United States commissioner of education began to show, in terms of the percentage of the total enrollment in the high school, a steady and substantial decline in enrollment[1] in the fundamental sciences.

The unrest symbolized by this decreasing enrollment led to a demand for a course of instruction to develop a content that relates more closely to interests and needs of children. This demand gave impetus to a movement to investigate the nature and needs of the learner and eventually culminated in a reorganization of the science curriculum in the high school. In this reorganization one of the

1 Extensive discussions of this decreasing enrollment in the specialized science courses are given in the following: Finley, C. W. *Biology in Secondary Schools and the Training of Biology Teachers,* Teachers College, Columbia University, Contributions to Education, No. 199, pp. 21-27.

Downing, E. R. *Teaching Science in the Schools.* Chapter 2. Bulletin No. 7, U. S. Bureau of Education, 1924. Statistics of Public High Schools, 1921-1922.

most significant and far reaching changes has been the elimination of the specialized sciences such as astronomy, physical geography and physiology from the first year of the four year high school and the introduction in their stead of a general science course.

The following statement by Hanna, a pioneer in the experiment with general science at Oak Park, Illinois, is indicative of the reasoning that was in the minds of some of the pioneers of this movement.

"It seemed to me," says Hanna[2], "that the science teaching of the high schools was not well adapted to the capacity of the pupils and was not so conducted as to challenge and hold their interest and, further, that it lacked in recognition of the psychology of youth and the ordinary principles of pedagogy as well as in its definiteness of relation to the real things of life. There seemed to me to be a necessity for working out some kind of a primary or elementary course that should be simpler and better adapted to the age of the pupils both in content and in method of presentation, and that should commend itself to them as being related to some other phases of life besides the machinery of schools.

"It seemed to me, also, that inasmuch as the phenomena of nature are presented to us unclassified, not grouped at all as physical, chemical, physiographical, biological, etc., and inasmuch as the interest of the pupils in meeting the problems connected with these phenomena could not very well be confined to one subdivision of them, all hankerings being suppressed for investigation in other fields, that there ought to be a course that would peep into all of these directions, or, as I have many times expressed it, it seemed to me that a bird's-eye view of the field of natural science was a necessity for good pedagogical reasons before taking up what I have sometimes called the 'toad's-eye view'."

The movement in the beginning developed slowly. Considerable opposition had developed mainly from two sources. First, many colleges and universities refused to give entrance credit for the work in general science. Second, a group of teachers of the special sciences, on the basis of a goodly number of weaknesses that they found in

2 Quoted from Eikenberry.

the organization of this new course, became antagonists of the movement. Some of the objections raised were valid and the oppositionists performed a real service by bringing these weaknesses forcibly to the attention of the sponsors of the newly organized science course. Naturally, in the earlier years of its evolution there was much blind groping and fumbling in the attempt to establish this work on a secure basis. But gradually there emerged from the failures and successes of the pioneer experimenters a substantial organization of subject matter which brought more support to the movement as a whole and which also softened the opposition. Many colleges and universities began to give entrance credit for general science, but the movement probably received its greatest impetus when leaders in the field of secondary education recognized it as worthy of a definite place in the high school curriculum. Since 1912 the movement has spread very rapidly with the result that, if the number of students enrolled in general science is taken as the criterion, it has become established as probably the most important and most popular science course in high school curricula.

The latest determination of the status of general science has been made by Pruitt[3]. Table I gives a summary of his findings as to the present status of general science as revealed through an analysis of printed matter from 42 states. With but one exception, all of these 42 states either require or recommend courses in general science. Pruitt in the same study analyzed 42 city high school courses of study and found only two that do not offer general science. Twenty-one cities required it, "at least of some students." These data show a very general belief as to the efficacy of a course in general science for ninth grade pupils.

3 Pruitt C. M. "Status of General Science as Revealed Through State and City Courses of Study," *General Science Quarterly.* 12: 367-381, January, 1928.

TABLE I

An Analysis of 42 State Courses of Study (From Pruitt)

STATE	Required	Recommended	7	8	9	Objectives Stated	Text Book or Reference	Apparatus
Alabama	*Yes	Yes	Yes	Yes	Yes	Yes		
Arkansas		"	"	"	"	"		
California		"	"	"			Yes	
Colorado		"	"	"	"	"		
Connecticut		"	"	"	"			
Delaware	"	"			"	"	"	
Florida	"	"			"	"		
Georgia		"			"	"	"	Yes
Idaho		"			"		"	"
Illinois		"			"			
Indiana	(Ignored)							
Iowa		Yes	"	"	"	"	"	"
Kansas		"	"	"	"	"	"	
Kentucky		"			"			
Louisiana		"	"	"	"		"	"
Maine		"	"	"		"		
Massachusetts		"	"	"		"		
Michigan		"			"	"	"	
Minnesora	Yes	"			"	"	"	
Missouri		"	"	"	"	"	"	"
Montana		"			"	"	"	"
Nebraska		"		"		"		"
Nevada		"		"		"	"	
New Hampshire		"	"	"	"	"	"	
New Jersey	"	"			"	"		
New Mexico		"			"	"	"	
New York		"	"	"	"	"		
North Carolina		"	"	"	"	"	"	"
North Dakota		"	"	"	"	"		"
Ohio		"	"	"	"	"	"	"
Oklahoma		"			"	"	"	"
Oregon	"	"	"		"	"	"	
Pennsylvania	"	"	"	"	"	"		
Tennessee		"			"			"
Texas	"	"		"	"	"		"
Utah	"	"	"	"	"	"	"	"
Vermont	"	"		"	"	"	"	
Virginia		"		"	"		"	
Washington		"			"	"		"
West Virginia	"	"			"	"	"	"
Wisconsin	"	"			"	"		
Wyoming		"			"	"		"

* A "Yes" in both the "required" and the "recommended" column means that general science was outlined as a required course in certain high schools (e. g., scientific course) or was an alternate requirement with some other science.

AIMS OF GENERAL SCIENCE

Along with the change from specialized to general science courses there has also crystallized a general agreement as to the principal aims and objectives of general science. Educational literature abounds with statements of what should constitute the primary aims of this new course. The writer has collected approximately seventy-five different lists of such aims and objectives. Most of these have appeared in professional journals, such as the General Science Quarterly or School Science and Mathematics. Some express the position taken by individuals while others represent the concensus of opinion of a large number of people most of whom may be considered leaders in the general science movement.

The Cardinal Principles of Secondary Education[4] have markedly influenced the writers of these aims so that a large number of repetitions appear. All restatements of any of the Cardinal Principles of Secondary Education have been excluded from the following list which contains only those statements that seem to have become usually accepted as the ones of first importance for general science.

1. To give such a knowledge of those facts, principles, and applications of science as will give a better understanding and lead to a better control of one's environment.
2. To provide training in the scientific method of solving problems.
3. To develop scientific attitudes.
4. To furnish children an opportunity to explore some of the content of all the sciences so that the learner may discover his individual interests and capacity.
5. To prepare for study of the special sciences.

4 Cardinal Principles of Secondary Education, U. S. Bureau of Education Bulletio, No. 35, 1918.

CHAPTER II

A REVIEW OF SOME PREVIOUS INVESTIGATIONS OF THE CONTENT OF GENERAL SCIENCE COURSES

Keen interest is usually manifested in the nature and organization of the instructional material of any new subject that appears in high school curricula. The frequent appearance in educational literature of reports of research studies into the content of the general science course is ample evidence that this has also been true of general science. A broad view of this literature makes it quite evident that these investigations have followed principally two lines of attack:

1. Analyses of samplings of textbooks of general science to reveal the number and per cent of pages devoted to the major divisions of science (physics, chemistry, biology, physical geography, etc.).

2. Analyses of samplings of textbooks of general science to show the principal science topics developed in them and the page space allotted to each.

The nature and some of the results of these investigations will be summarized here as a background to the textbook analysis presented and described in the next chapter of this monograph. It seems expedient to give a cursory rather than a thorough review of these studies in order that this chapter may be kept within the bounds set by a consideration of its maximum contribution to the main investigations presented in this study.

STUDIES OF THE FIRST TYPE

One of the earliest investigations to appear in this field was made by Trafton[1]. He made a comparative study of seventeen general science textbooks that had appeared between the years 1912 and 1919 to determine the number and percentage of the combined pages of

1 Trafton G. H., "Comparison of Textbooks in General Science," *General Science Quarterly* 4:450-454.

all seventeen texts that were devoted to each of the special sciences. Table II gives the results of this study.

TABLE II

Number and Percentage of Pages Devoted to the Special Sciences in 17 General Science Texts (From Trafton)

Science	No. of pages	Percentage of pages
Physics	2412	33.5
Hygiene	1307	18.2
Physical Geography	1047	14.6
Biology	934	13.0
Chemistry	743	10.3
Agriculture	541	7.5
Astronomy	207	2.9

Conspicuous among the earlier investigations in this field is the contribution by Webb[2] reported in 1921. He made, among other things, a quantitative analysis of the subject matter content of 18 general science textbooks published prior to the spring of 1919. Table III shows his findings as to the number of combined pages of the text devoted to eight large science groups.

TABLE III

Number of Combined Pages of 18 General Science Texts Devoted to 8 Large Science Groups (From Webb)

Science	No. of Pages	Science	No. of Pages
Physics	2,212.5	Physiography	1,264.5
Biology	908.0	Physiology	885.5
Chemistry	632.0	Household Arts	343.5
Astronomy	271.5	Miscellaneous	120.5

Heinemann[3] in a study of the scientific principles developed in general science analyzed the subject matter content of twenty text-

2 Webb, H. A. *General Science Instruction in the Grades,* George Peabody College for Teachers, Contributions to Education, No. 4, Part 1, pp. 1-40.

3 Heinemann, A. M. "A Study of General Science Textbooks," *General Science Quarterly,* 13:11-23, November, 1928.

books in general science. She reports the following rank order of the major sciences that are used in developing the general science course as determined on the basis of space given in the combined twenty textbooks:

1. Physics
2. Biology
3. Geography, Astronomy and Meteorology
4. Physiology
5. Geology
6. Chemistry.

Overn[4] in 1921 analyzed the subject matter content of twelve textbooks in general science that had appeared prior to 1920. His findings as to the division of the subject matter of four major science fields in these combined texts are summarized in Table IV.

TABLE IV

Summary, Showing Division of Subject Matter in Twelve Books According to Four Fields of Science (From Overn)

Author	Physics	Chemistry	Biology	Physiography	Total
Barber	183.6	58.0	111.1	288.3	581.0
Caldwell & Eikenberry	102.0	9.4	121.95	149.95	383.3
Clark	152.65	62.5	146.2	92.4	453.75
Elhuff	170.4	35.45	141.6	52.55	400.0
Hessler	141.2	50.6	179.5	79.5	450.8
Hodgdon	201.2	42.85	129.2	166.25	539.5
Lake	143.85	35.15	136.15	121.35	436.5
Pease	71.25	27.15	84.1	129.9	312.5
Smith & Jewett	245.7	78.25	144.6	135.7	604.25
Snyder	109.35	20.6	149.35	267.9	547.2
Trafton	166.65	.4	298.7	66.1	535.85
Van Buskirk & Smith	108.7	22.2	165.1	81.7	377.7
	1796.55	446.55	1807.55	1571.6	5622.25

4 Overn, O. E. An Analysis of General Science Textbooks, unpublished Master's Thesis, University of Chicago.

It will be noted in Overn's data that the science of biology leads in the number of pages devoted to it in the textbooks he analyzed while physics ranks second. In all other analyses of this type physics was found to rank first and biology ranked second or third. This seeming anomaly is easily explained however, by the fact that Overn classified the science topics found in textbooks into four fields of science whereas other investigators split the topics into seven or eight groups. Some of the topics included by Overn under the science of biology were placed by other investigators under the sciences of physiology, hygiene or agriculture. By simply manipulating the data in Table V, which are the findings of Klopp[5] from an analysis of nine general science textbooks, this point is made clear. By combining the percentage for physiology (9.1) with the percentage for biology (24.5) the percentage for biology becomes 33.6, giving biology a rank of one and physics with 32.7 per cent a rank of two.

TABLE V

The Average Specific Science Offering by All Authors (From Klopp)

Science	Per Cent	Science	Per Cent
Physics	32.70	Physical Geography	14.00
Chemistry	8.90	Home Economics	4.40
Biology	24.50	Physiology	9.10
Agriculture	2.04	Astronomy	5.06

One major generalization can be drawn from this series of investigations, namely, that general science textbook writers in the development of units of subject matter have drawn the instructional material primarily from the three major science fields of physics, biology and physiography.

5 Klopp, W. G. "A Study of the Offerings of General Science Texts," *General Science Quarterly*, 11:236-246, May, 1927.

STUDIES OF THE SECOND TYPE

Howe[6], in 1919, formulated lists of fundamental and optional topics to be developed in general science courses. He first analyzed textbooks, syllabi and courses of study to determine the topics contained. He then submitted a list of the topics which he had found to eighty teachers of general science to mark those topics which they considered essential and those which they considered of value as supplementary material. Two lists are given in his report; one showing the fundamental topics or minimum essentials of general science and the other showing the optional material.

Webb[7] as a part of the investigation previously referred to in this chapter determined the subject matter content of eighteen general science textbooks. Table VI showing the number of combined pages of the eighteen texts devoted to each of the topics listed under the caption of physiology-hygiene is a sample of Webb's analyses. In a similar manner the topics appearing under the other seven science groups are given but they are too extensive to be reproduced here.

6 Howe, C. M. "Can and Should General Science Be Standardized?" *School Science and Mathematics*, 19:248-255, May, 1919.

7 Webb, H. A. op. cit.

TABLE VI

Major Topics in Physiology-Hygiene Developed in High School General Science Texts Up to 1919 (From Webb)

Topic	No. of Books	No. of Pages
1. Bacteria and Contagious Diseases	15	206
2. Pure Water Supply, How Obtained	15	98
3. Insect Carriers of Disease	13	54.5
4. Respiration	13	50.5
5. Digestion	12	79.5
6. The Eye	12	60.0
7. Narcotics and Stimulants	12	52.0
8. The Circulation	10	42.0
9. Sewage Disposal	7	35.5
10. The Nervous System	7	32.5
11. The Ear	7	13.0
12. First Aid	6	34.5
13. The Skeleton, Bones	6	21.5
14. Excretion	5	23.5
15. Muscles	5	13.5
16. Pure Air. Harmfulness of Dust	5	12.0
17. Sanitary Plumbing	4	17.5
18. Miscellaneous, Discussion of	3	26.5
19. Animal Parasites, Tapeworm, Hookworm	3	2.5
20. The Special Senses, Miscellaneous	2	3.5
21. Touch	2	2.0
22. Taste	2	1.5
23. Smell	2	1.0
24. Ductless Glands	1	2.5
Total pages of Topics in Physiology-Hygiene		885.5

Weckel[8] analyzed fourteen general science textbooks, published prior to 1921, to determine the principal topics of science developed in them.

8 Weckel, Ada L. "Are any Principles of Organization of General Science Evidenced by Present Textbooks in the Subject?" *School Science and Mathematics*, 22:44-51. January, 1922.

The following list of topics, showing the number of textbooks in which each is treated, is the result of Weckel's analysis.

I. All Fourteen Textbooks.
   1. Atmospheric pressure.
   2. Principle of and kinds of thermometers.
   3. Definition and applications of humidity, dew point, condensation, and saturation.

II. Thirteen of the Fourteen Textbooks.
   1. Oxidation.
   2. Transference of heat: conduction, convection, radiation.
   3. Soils, origin and composition.
   4. Study of weather maps.

III. Twelve of the Fourteen Textbooks.
   1. Composition of atmosphere.
   2. Winds, cause of and general circulation.
   3. Molds and bacteria: structure, development, relation to diseases and decay.
   4. Foods and nutrition.

IV. Eleven of the Fourteen Textbooks.
   1. Study of the cell.
   2. Calorie, value of.
   3. Structure and function of parts of human eye.
   4. Heat, nature and origin.
   5. Electricity, elementary presentation of
   6. Sanitation and diseases: germs, toxins, antitoxins, disinfectants, sterilization, vaccines, etc.

V. Ten of the Fourteen Textbooks.
   1. Seasons, cause of.
   2. Gravity, definition.
   3. Storms, causes and common types.
   4. Pumps.
   5. Sewage Disposal.
   6. Types of electric cells.
   7. Lighting systems: kerosene, gas, electric, acetylene.

VI. Nine of the Fourteen Textbooks.
   1. Properties of matter.

2. Elements and compounds.
3. Plants: structure and function of roots, stems, leaves and flowers.
4. Molecular theory.
5. Water power and its application.
6. Manufacture of artificial ice.
7. Steam engine, principle of action and application.
8. Sound, nature of.
9. Light, nature and properties.
10. Carbon dioxide: source, role in nature, fire extinguisher.
11. Cell division and reproduction in plants and animals.
12. Machines: lever, screw, pulleys, wheel and axle, inclined plane.
13. Solution, especially as applied to hard and soft water.
14. Vaporization.

VII. Eight of the Fourteen Textbooks.

1. Drainage and irrigation.
2. Erosion.
3. Distillation.
4. Solar system.
5. Physical and chemical changes.
6. Heating systems.
7. Magnetism.
8. Acids, bases, and neutralization.
9. Injurious insects.
10. Osmosis.
11. Filtration.
12. Expansion of solids, liquids and gases.
13. Electric bell, telephone, telegraph.
14. Ventilation, principle of and different systems.
15. Combustion.

VIII. Seven of the Fourteen Textbooks.

1. Siphon.
2. Human ear, parts and functions of each.
3. Weathering.
4. Fertilization.

5. Lenses, kinds.
6. Day and night, cause.
7. Capillarity.
8. Gasoline engines.
9. Plant nutrition.

IX. Six of the Fourteen Textbooks.

1. Metric system.
2. Density and specific gravity.
3. Archimedes' principle.
4. Survey of animal kingdom.
5. Time, standard, etc.
6. Electrolysis.
7. Fuels and carbon compounds.

X. Five of the Fourteen Textbooks.

1. Human body, structure of.
2. Energy: kinds, measure for.
3. Life processes in animals.
4. Pasteurization.
5. Properties of protoplasm.
6. Mechanics of respiration.
7. Pollination and fertilization in plants.

XI. Four of the Fourteen Textbooks.

1. Seed dispersal.
2. Glaciers.
3. Latitude and longitude.
4. Cohesion and adhesion.
5. Wind power.
6. Human voice.
7. Earthquakes and volcanoes.
8. Parasites.
9. River development.
10. Economic botany.

XII. Three of the Fourteen Textbooks.

1. Analysis and synthesis.
2. Boyle's law.
3. Hydraulic press.

Overn, Iler, and Heinemann, under the direction of Professor Downing of the University of Chicago, analyzed the subject matter content of twenty-five textbooks in general science. Overn analyzed twelve texts published prior to 1920 and Iler analyzed thirteen texts published since 1920. The subject matter of these twenty-five texts was analyzed on the basis of twenty large topics subdivided into 131 minor topics. An excellent summary[9] showing the amount of page space devoted to the major and minor topics in each of the texts has been reported in the General Science Quarterly, May, 1928.

Heinemann[10] analyzed twenty general science textbooks to determine primarily how much importance was accorded principles of science and to what extent problematic situations (applications of principles) were used to fix the principles in the pupils' minds. A summary of the results of this study is given in the General Science Quarterly, November, 1928, showing the number of generalizations, the square inches of space devoted to generalizations, the percentage of space devoted to generalizations, the number of principles applied, the square inches of space devoted to applications, the percentage of space devoted to applications. All of these data are given for each text. Unfortunately, the author has not reported what principles are most commonly developed in the general science courses which in all probability is the part of the investigation that would prove most valuable and interesting to teachers of general science.

SOME GENERAL CONCLUSIONS ARRIVED AT BY THE AUTHORS OF THE STUDIES REPORTED

In this chapter only those data could be presented that would show the nature and trend of the researches in the subject matter of general science. The following are some of the more representative conclusions reached by the workers on these investigations:

1. "There is no concensus of opinon as to what should be treated in a text in general science and there has been no increase in the

9 Overn, Iler, and Heinemann (Elliot R. Downing, Editor), "An Analysis of Textbooks in General Science," *General Science Quarterly*, 12:509-516, May, 1928.

10 Heinemann, A. M., "A Study of General Science Textbooks," *General Science Quarterly*, 13:11-23, November, 1928.

unanimity of opinion in this matter in the late books as compared with the earlier ones." Overn, Iler, Heinemann, and Downing, May, 1928.

2. "General Science textbooks are not devoting much space to a mastery of the principles of science." Heinemann & Downing, 1928.

3. The major portion of general science is developed from three major science fields, namely; physics, biology and physiography. (This conclusion is supported by all of the investigators.)

4. Authors of general science textbooks "do agree upon the major objectives to be realized." Heinemann, Klopp, & Weckel.

5. "The authors of general science textbooks fail to agree upon both type and amount of content offering for the realization of the objectives of general science." Klopp, 1927.

CHAPTER III

THE BASIC INSTRUCTIONAL MATERIAL OF GENERAL SCIENCE

In this chapter a detailed analysis of the subject matter of general science is given. This analysis was made for two reasons:

First, in order to know what facts, principles and applications of science constitute the nucleus of the modern general science course.

Second, to furnish an objective basis upon which to build the tests of achievement that were used later in this investigation to determine the degree of mastery of the instructional material of general science. Previous investigations of the subject matter content of general science courses have been limited, for the most part, to a determination of the large topics developed in them. It was necessary in this study to know not only the large topical divisions but also the basic facts, principles, and applications of science developed in these topics as well. Furthermore, in many of these analyses textbooks that are now obsolete or obsolescent were included and which are probably having little influence on present day introductory general science classes.

Investigations of the content of general science, up to this time, indicate that while there is agreement as to the major aims of the course there is by no means a unanimity of opinion as to what subject matter is necessary to accomplish these goals. This condition is to be expected, however, when we remember that the instructional material of general science is drawn from the whole field of science, which is both rich and extensive, and also that general science is relatively new in the high school curriculum.

It does not require a very extensive examination of modern general science textbooks, however, to see that there is a considerable degree of similarity in science content. Should a text appear that was different from every other text it would certainly be considered unique.

In fact this part of the investigation proceeds on the hypothesis that a common nucleus of subject matter in general science has crystallized and it becomes our problem at this time to discover what that basic instructional material of general science is or in other words to ascertain what facts, principles, and applications of science are most commonly used in developing the most commonly accepted units in general science.

At the present time the subject matter used in high school general science classes is determined quite largely by general science textbooks. This statement is not an unsupported assertion but is based upon the results obtained by Curtis[1] from a questionnaire sent to 206 selected high schools to ascertain the current practices in these schools with respect to the use of texts, syllabi, and extensive reading in general science.

Since general science textbooks very largely determine the nature of the content of the general science course, the solution of our problem then rests in an analysis of these texts.

General science being a comparatively new subject in the curriculum of the high school, the nature and organization of its subject matter quite naturally undergoes frequent changes. Because of this fact the recency of publication of a text was chosen as the criterion for the selection of the textbooks to be included in this analysis.

Seven general science textbooks that were published at about the time this study was begun were finally selected to be analyzed. With but two exceptions all[2] have been published since 1925. The other two were published in 1923.

1 Curtis, F. D., "Some Values Derived from Extensive Reading of General Science." Teachers College, Columbia University Contributions to Education, No. 163, Bureau of Publications, Teachers College, Chapter 1, pp 4-10, 1924.

2 The seven texts used in this analysis were:
Bowden, *General Science,* P. Blakiston's Son & Co., 1923.
Caldwell and Eikenberry, *Elements of General Science,* Ginn & Co., 1926
Hunter and Whitman, *Civic Science in Home and Community,* American Book Co., 1923.
Pieper and Beauchamp, *Everyday Problems in Science,* Scott, Foresman and Company, 1925.
Van Buskirk and Smith, *The Science of Everyday Life,* Houghton, Mifflin Co., 1925.
Webb and Didcoct, *Early Steps in Science* D. Appleton Co., 1925.
Wood & Carpenter, *Our Environment,* Allyn & Bacon, 1927.

METHOD OF THE ANALYSIS

Each page of the seven texts was carefully read and brief statements recorded of the facts, principles, and applications of science developed in them. In some cases a single statement was used to cover more than a single fact or principle. For example, if the siphon was explained in a text, the phrase, "The operation of a siphon" was given to cover all the facts and principles necessary for its explanation as there is only one correct explanation of the operation of a siphon. This was done only where there was no doubt as to what instructional material was involved. Quite frequently statements had to be reduced to their lowest terms. For example, the phrase, "the physical properties of air" would not be satisfactory because of the number of different physical properties of air and the variation of opinion of authors as to which ones should be developed. Each physical property of air was listed separately. The following sample statements indicate how this was done:

1. Air occupies space.
2. Air has weight and exerts pressure.
3. Air can be compressed.
4. Air is elastic.

After the analysis of all seven texts was completed, the facts, principles, and applications of science were grouped under unit headings to show the frequency of their occurrence in the seven texts. No material was considered basic or included in this grouping unless it occurred in at least a majority of the texts.

The following are the titles of the units under which the results of the analysis of the texts will appear:

1. Atmosphere and Weather.
2. Water, Water Supplies, and Sewage Disposal.
3. The Earth and Other Heavenly Bodies.
4. Rocks and Soil.
5. Foods and Nutrition.
6. Life on the Earth.
7. Energy, Work, and Machines.
8. Heating and Lighting.

9. Electricity and Communication.
10. Travel and Transportation.
11. Clothing.
12. Homes and Building Construction.

There is no complete agreement among authors and teachers of general science as to how the instructional material of general science should be organized and developed except that the units of subject matter should be organized from the point of view of our environment without any regard to the major divisions of science. An example of this lack of uniformity is the lift pump. One author will explain the lift pump in the unit on "Atmosphere," apparently because it is an application of atmospheric pressure, while another author may develop the lift pump in connection with the unit on "Water and Water Supplies," because the lift pump is a means of securing water. Sound is another example. Some authors develop topics of sound in connection with the unit on "Atmosphere" because air is a medium of sound transmission while another author considers sound in connection with the unit on "Communication."

There is a considerable degree of uniformity in the texts, however, and much of the material could be classified quite readily. In cases like the examples just cited the placement of such items under the unit headings was determined by the writer's personal judgment.

THE RESULTS OF THE ANALYSIS

The following tables present the results of the textbook analysis showing the basic facts, principles and applications of science developed in general science. The number of texts in which they occur is a measure of their relative importance. All of the science included in these tables, excepting the last two, may be considered the nucleus around which the modern course in general science is built, and is therefore the best basis upon which to build tests of achievement in general science.

TABLE VII-A

Unit 1—Atmosphere and Weather

A. Physical properties and mechanics of gases	Frequency
1. Air occupies space	7
2. Air has weight and exerts pressure	7
3. Air can be compressed	7
4. Common applications of air pressure in every day life	7
5. Effects of heat and cold on gas volume	7
6. Heating causes convection currents in air	7
7. Application of convection of air in hot air furnace	7
8. Operation of a lift pump	7
9. Why water does not rise above 33 feet in a lift pump.	7
10. Definition of a barometer	7
11. The construction and operation of a mercurial barometer	7
12. Air is elastic	7
13. Air is buoyant	7
14. Fahrenheit and Centigrade thermometers	7
15. The construction and operation of an aneroid barometer	6
16. Aneroid barometer used by aviators to determine altitude	6
17. Torricelli made first mercurial barometer	6
18. Operation of a force pump	6
19. Air pressure at sea level about 15 lbs. per square inch	6
20. Mercury is 13.6 times heavier than water	6
21. Operation of a siphon	5
22. Air pressure decreases with altitude	5
23. How to calculate Fahrenheit degrees to Centigrade and vice versa	5
24. Circulation of air in a refrigerator	5
25. The necessity of air pressure for breathing	5
26. Operation of a compression pump	4
B. Chemical Composition	
1. Air is a mixture of gases	7
2. The chief gases in the air	7
3. Necessity of air for burning	7
4. Carbon dioxide turns lime water milky	7
5. The three states of matter	7
6. Meaning of term chemical compound	7
7. The air consists mostly of oxygen and nitrogen	7
8. Products of burning are water and carbon dioxide	7
9. Oxygen of air supports combustion	7
10. Nitrogen of air is an inactive gas which dilutes the oxygen	7

11. Definition of oxidation	6
12. Definition of term element	6
13. How to prepare carbon dioxide	6
14. Difference between chemical and physical change	5
C. Atmospheric moisture	
1. Definition of evaporation	7
2. Definition of condensation	7
3. Definition of term humidity	7
4. Relation of relative humidity to individual comfort	7
6. Definition of relative humidity	6
6. Determination of relative humidity by use of wet and dry bulb hygrometer	6
7. Rate of evaporation depends upon surface exposed, air currents, temperature, and humidity	6
8. Evaporation of liquid requires heat	6
9. Air is saturated when it contains all the water it can hold	6
10. Fanning causes cooling by increasing rate of evaporation	5
11. Bodily temperature is regulated by evaporation of perspiration	5
D. Weather	
1. Definition and cause of wind	7
2. Where moisture in air comes from and the conditions which produce rain	7
3. Conditions which produce dew	7
4. Formation of fog	7
5. Formation of clouds	7
6. Weather in cyclones and their movements	7
7. Weather in anticyclones and their movement	7
8. Chief causes of unequal rainfall in different parts of the United States	7
9. Characteristics of cumulus clouds	7
10. Weather conditions indicated by a rising or falling barometer	7
11. Use of weather maps showing high and low pressure areas	7
12. Cause and description of thunderstorms	6
13. Effect of prevailing winds on climate	6
14. Conditions which produce frost	6
15. Characteristics of cirrus clouds	6
16. Effect of large bodies of water on climate	5
17. Important wind belts over Earth's surface	5
18. Conditions which produce snow	5
19. Characteristics of nimbus clouds	5
20. Characteristics of stratus clouds	5
21. How the U. S. Weather Bureau collects data and forecasts weather	5
22. The characteristics of a tornado	5
23. Climate and factors which determine climate	5

24. Causes of land and sea breezes	4
E. Respiration in plants and animals	
1. Importance of humidity in ventilation	7
2. Importance of circulation of air in ventilation	7
3. Relation of oxygen supply to ventilation	7
4. Carbon dioxide is a non-poisonous gas	7
5. Hot, dry air in a room does not provide a healthy environment	7
6. Know the importance of pure air to health	7
7. Know the dangers of dust in the air	7
8. Relation of plants to air supply	7
9. Methods of ventilation	7
10. Causes of sticky oppressive weather	7
11. Temperature control a very important factor in ventilation	7
12. Water vapor is given off in breathing	7
13. Comparison of content of inspired and expired air	6
F. Sound transmission	
1. The nature of sound	7
2. How sound is produced	7
3. How sound is transmitted	7
4. How pitch of sound is produced	6
5. Structure of the human ear	5
6. How sensation of hearing is produced	5
7. Speed of sound	4
8. How sounds made by human voice are produced	5
9. Reproduction of sound by phonograph	4
10. Sound produced by musical instruments	4

TABLE VII-B

Unit 2—Water, Water Supplies, and Sewage Disposal

A. Physical Properties	Frequency
1. Boiling points of water: Centigrade and Fahrenheit	6
2. Freezing points of water: Centigrade and Fahrenheit	6
3. Water may exist as three states of matter	6
4. Expanding steam exerts pressure which is basis for operation of the steam engine	6
5. Water changing to steam increases in volume	5
6. Water contracts on cooling to 4° C. when it begins to expand	5
7. Freezing point of water and melting point of ice are the same	5
8. Reducing pressure on water lowers boiling point	4
9. Increasing pressure on water raises boiling point	4
10. Cubic foot of water weighs about 62.5 pounds.	4

B. Chemical Properties
1. Differences between hard and soft water ---------- 7
2. Some minerals are usually dissolved in our water supply ---------- 6
3. Boiling water removes temporary hardness ---------- 6
4. Water is a carrier of typhoid fever bacteria ---------- 6
5. Typhoid fever may be prevented by inoculation ---------- 6
6. Water is a chemical compound ---------- 5
7. Water is composed of two parts hydrogen to one part oxygen ---------- 5
8. Permanent hardness of water is removed by chemicals ---------- 5
9. Cause of temporary hardness of water ---------- 5
10. Cause of permanent hardness of water ---------- 4
11. Water is a good solvent ---------- 4

C. Mechanics of Liquids
1. Cause of water rising in pumps ---------- 7
2. Definition of capillary action ---------- 7
3. Cause of flow of water in a siphon ---------- 7
4. Objects immersed in water buoyed up by a force equal to weight of water displaced ---------- 5
5. Pressure of water in a standpipe equal to height times density ---- 4

D. Distillation
1. Definition of distillation ---------- 7
2. Distillation will free water of its impurities ---------- 7

E. Evaporation
1. Heat is taken in during evaporation ---------- 7
2. Importance of evaporation in nature ---------- 6
3. Principles of refrigeration ---------- 6
4. Use of refrigeration in cold storage ---------- 6
5. Melting ice takes heat from surrounding air and objects ---------- 6

F. Water Supply
1. Importance of source of water supply not being contaminated ---------- 7
2. Adequate supply of pure water essential for health ---------- 7
3. The sources of our water supply ---------- 7
4. Most dangerous impurity in water is usually bacteria ---------- 7
5. Purification of water by boiling ---------- 7
6. The common classes of impurities in water are sediment, bacteria, and dissolved substances ---------- 6
7. Purification of water by filtration ---------- 6
8. Shallow wells are usually unsafe ---------- 6
9. Definition of an artesian well ---------- 5
10. Purification of water by chemicals ---------- 5
11. Common methods of distributing water to cities and towns
(a) Gravity system ---------- 5

(b) Pressure system by pumps ---- 4
(c) Pressure system by use of standpipe ---- 4

G. Sewage Disposal
1. Sewage is a dangerous source of contamination of water supply---- 7
2. Improper sewage disposal is menace to health of the community---- 7
3. Methods of sewage disposal ---- 7
4. Safest method of sewage disposal is in septic tanks ---- 7
5. The use of cesspools ---- 7
6. Wells should be deep and properly covered to insure pure water --- 6
7. Use of contact filter beds to destroy sewage ---- 4

H. House Piping and Heating
1. Convection currents in water ---- 7
2. Operation of the hot water heating system ---- 7
3. Water expands when heated ---- 7
4. Use of water traps in drain pipes ---- 6
5. Common types of faucets used
(a) Screw ---- 6
(b) Spring ---- 5
(c) Compression ---- 4
6. Operation of flush tanks ---- 5
7. Operation of steam heating plants ---- 5
8. Convection in hot water tank attached to coal range or furnace ---- 5

TABLE VII-C

Unit 3—The Earth and Other Heavenly Bodies

A. Earth's Relation to the Universe — Frequency
1. The bodies that make up the solar system ---- 7
2. The number and names of the planets ---- 7
3. The sun is a star ---- 7
4. The relative distance, size and position of the planets ---- 7
5. Meaning of term constellation ---- 7
6. Explanation of the great distances of stars from the earth ---- 7
7. Sun and other stars evolve their own light ---- 7
8. Sun is the source of all our energy ---- 7
9. The moon and planets give off light reflected from the sun ---- 7
10. Comparison of the moon with the earth ---- 6
11. Light travels 186,000 miles per second ---- 6
12. The sun is the center of our solar system ---- 6
13. Distance of sun from the earth is approximately 93,000,000 miles --- 6
14. Cause of the phases of the moon ---- 6

15. The force which holds the heavenly bodies in their positions is gravitation ---- 5
16. Identification of the constellation Big Dipper ---- 5
17. Identification of the constellation Little Dipper ---- 5
18. How to locate North Star by means of the Big Dipper ---- 5
19. Main differences between stars, planets and moons ---- 5
20. Use of telescope to study stars ---- 5
21. Cause of an eclipse of the moon ---- 5
22. Cause of an eclipse of the sun ---- 5
23. Telescope was invented by Galileo ---- 5
24. The idea that the heavenly bodies exert evil influences on people is unscientific ---- 4
25. Moon is covered with mountains and craters ---- 4
26. Explanation of meteors ---- 4

B. Earth and Its Seasons

1. Causes of day and night ---- 7
3. Causes of seasons of the year ---- 6
3. Definition of latitude and longitude ---- 4
4. Standard time belts of the United States ---- 4
5. Definition of parallels and meridian ---- 4

TABLE VII-D

Unit 4—Rocks and Soil

A. Nature of the Earth's Crust	Frequency
1. Running water helps to produce soil	7
2. Freezing water and frost help to produce soil	7
3. Explanation of irrigation	7
4. Irrigation projects undertaken by United States government in the West	7
5. Definition of erosion	6
6. Type of soil which holds the water best	6
7. Relation of capillary action in soil to farming	6
8. Importance of good soil drainage	6
9. Artificial drainage of soil	6
10. Chief sources of water for irrigation	6
11. Use of manure as a fertilizer	6
12. Use of commercial fertilizers (nitrates)	6
13. How the leguminous plants get nitrogen from the air	6
14. Beans, clover, alfalfa, and peas are common legumes	6
15. All plants take from the soil chemical elements that must be	

replaced by fertilizing	6
16. How swampy lands are reclaimed by soil drainage	6
17. Glaciers are erosive agents	6
18. Different plants require different proportions of chemical elements for their growth	5
19. How soils are classified	5
20. The kinds of soil	5
21. Definition of humus	5
22. Function of bacteria in the soil	5
23. Meaning of term water-table line	5
24. Changing position of the water-table line	5
25. Wind is an erosive agent	5
26. Plants and animals help to produce soil	5
27. Explanation of dry farming	4
28. Temperature changes aid erosion	4
29. Factors determining soil fertility	4
30. Origin and nature of sedimentary rocks	4
31. Origin and nature of igneous rocks	4
32. Origin and nature of metamorphic rocks	4
33. Work of vegetation in preventing erosion	4

TABLE VII-E

Unit 5—Foods and Nutrition

A. Necessity and Production	Frequency
1. Food is needed for growth and repair of body	7
2. Food furnishes heat and energy to body	7
3. Protein foods are tissue builders	7
4. Carbohydrates and fats furnish fuel for heat and energy	7
5. Minerals are needed for building bone and teeth	7
6. Comparison of human body with a machine	6
7. Necessity of vitamines for health	6
8. Carbohydrates are needed in largest quantity in foods	6
9. Food is manufactured by green plants	6
10. Water constitutes about 2-3 of weight of the body	5
11. The chemical elements found in the body	5
12. Foods are stored in leaves, stems, seeds, fruits, and roots of plants	5
13. Proteins are needed in least quantity in foods	4
B. Measurement of Food	
1. Proper proportion of food nutrients needed by average person	6
2. Definition of term calorie	6

3. Unit of measurement of food energy value is the calorie ---------- 6
4. Amount of food needed by individuals depends upon occupation, climate, age, and size ---------- 5
5. Definition of Calorie ---------- 4

C. Composition

1. Lists of common foods rich in each food nutrient ---------- 7
2. Common foods rich in vitamines ---------- 7
3. Milk as a food containing all the food nutrients ---------- 7
4. The food nutrients are proteins, carbohydrates, fats, mineral matter and water ---------- 7
5. Vitamines are classified as A, B, C, D ---------- 6
6. Sugar and starch are known as carbohydrates ---------- 6
7. How to test for the food nutrients, carbohydrates, fats and proteins-- 5
8. Carbohydrates and fats contain the elements, carbon, oxygen and hydrogen ---------- 5
9. Cheap sources of protein foods ---------- 5

D. Digestion and Assimilation

1. Foods must be changed to soluble form before they can be used by the body ---------- 6
2. Enzymes cause chemical changes in food and make it soluble ------ 5
3. The enzyme ptyalin is found in saliva, which begins the digestion of starch ---------- 6
4. Parts of the food tube and their function ---------- 5
5. Digestion of proteins is begun in the stomach ---------- 5
6. Course of blood through the circulatory system ---------- 5
7. How waste materials are eliminated from the body ---------- 5
8. Most absorption of food takes place in the small intestine ---------- 5
9. Chewing food into small particles aids digestion ---------- 5
10. Care of the teeth ---------- 5
11. Enzymes in the intestines and pancreatic juice ---------- 4

E. Diet

1. The need of a variety of foods ---------- 7
2. Lack of vitamines in the diet causes certain diseases ---------- 7
3. Pasteurization of milk as a method of safeguarding milk from disease germs ---------- 6
4. Importance of pure milk and dangers of impurities ---------- 5
5. Alcohol is not a food ---------- 5
6. Coffee and tea are not foods ---------- 4

TABLE VII-F

Unit 6—Life on The Earth
Plant Life

	Frequency
A. Cell Structure and Activities	
1. Definition of protoplasm	6
2. Main parts of a cell are cellwall, protoplasm, nucleus	5
3. Cell wall is made of cellulose and gives shape to cell	4
B. Parts of Plants and Their Functions	
1. Roots of plants are covered with root-hairs	7
2. Function of roots of plants	5
(a) Anchor plants	
(b) Absorb soil water	
(c) Store up food	
3. Function of stems of plants	5
(a) Hold leaves up to sunlight	
(b) Carry water to the leaves	
(c) Carry sap back to roots	
4. Function of leaves of plants	5
(a) Contain stomata through which transpiration takes place.	
(b) Place of manufacture of foods in plants	
C. Food Production	
1. Water and carbon dioxide are needed by plants to make starch	7
2. The leaf is the plant's food factory	7
3. Leaves that contain chlorophyll manufacture food in presence of light only	7
4. The by-product of food making in plants is oxygen	7
5. Carbon dioxide enters through stomata of leaves	7
6. Soil water enters plants through root-hairs	7
7. Definition of osmosis	5
8. Plants take nitrogen from the soil	5
9. Green plants help purify the atmosphere	5
10. Plants derive energy from sunlight	5
11. Definition of photosynthesis	4
D. Reproduction	
1. Flowers of plants contain the organs of reproduction	6
2. Nature and position of petals, sepals, pistils and stamens of the flower	6
3. The ovary produces egg cells	6
4. Stamens produce the pollen	6
5. Petals attract insects to the flower	6
6. Explanation of fertilization in plants	6

7. Explanation of terms variation and heredity ---------- 6
8. The position and function of the style ---------- 5
9. The position and function of the stigma ---------- 5
10. The position and function of the anther ---------- 5
11. Explanation of staminate and pistillate flowers ---------- 5
12. The embryo of new plant is in the seed ---------- 5
13. Definition of pollination ---------- 5
14. Explanation of cross-pollination ---------- 5
15. Common agencies of cross-pollination ---------- 5

Animals

A. Human Physiology
1. Circulatory system of man ---------- 7
2. Digestive system of man ---------- 7
3. All life comes from life ---------- 7
4. Use of term reproduction ---------- 7
5. New life produced by uniting of sperm and egg cells ---------- 6
6. Reproduction of a frog ---------- 5
7. Structure of nerve cells ---------- 4

B. Insects and Diseases
1. Life history of the fly ---------- 7
2. Flies spread disease germs ---------- 7
3. Breeding places of flies ---------- 7
4. Life history of the mosquito ---------- 7
5. Breeding place for mosquitoes ---------- 7
6. How to destroy mosquitoes by pouring oil on water ---------- 7
7. How disease germs are transmitted ---------- 7
8. A strong constitution is an effective barrier against disease germs -- 7
9. How to combat flies ---------- 7
10. Malaria is spread by mosquito anopheles ---------- 7
11. Yellow fever is spread by mosquito stegomyia ---------- 7

Bacteria, Yeast, and Molds

1. The most common kind of disease germs are called bacteria ------ 7
2. Bacteria give off a poison called toxin ---------- 7
3. Use of anti-toxin to combat disease ---------- 7
4. Importance of good health for prevention of disease ---------- 7
5. Conditions which are favorable to growth of bacteria, yeast and mold ---------- 7
6. Bacteria, yeast, and molds cause food to decay ---------- 7
7. Bacteria are one celled plants ---------- 6
8. How bacteria reproduce ---------- 6

9. White corpuscles of blood attack and destroy bacteria ---------- 6
10. Wild yeast plants are present in the air ---------- 6
11. Certain bacteria are very useful to man ---------- 6
12. Use of heat and chemicals to destroy bacteria, yeast, and molds ---- 6

Hygiene and Sanitation

1. Harmful effects of alcohol and tobacco ---------- 7
2. Definition of vaccination ---------- 5
3. Definition of immunity ---------- 5
4. How to prevent epidemics ---------- 5
5. Use of disinfectants ---------- 5
6. Use of fumigation ---------- 4

TABLE VII-G

Unit 7—Energy, Work, and Machines

A. Work of running water — Frequency
1. Use and description of water turbines in power plants to run dynamos ---------- 6
2. Application of the force of running water to water wheels ---------- 5
3. The importance and possibility of harnessing all streams and falls to produce electricity ---------- 5
4. Three types of water wheels; overshot, undershot, and breast wheel 4

B. Work of Simple Machines
1. Definition of a lever and the different classes ---------- 7
2. Examples and applications of levers ---------- 7
3. The inclined plane and its uses ---------- 7
4. The wheel and axle and its use ---------- 7
5. Definition of term machine ---------- 6
6. The use of the screw ---------- 5
7. Use of pulleys and their advantages ---------- 5
8. Use of the wedge ---------- 6

C. Measurement and Kinds of Energy
1. Illustrations of transformations of energy in every day life ---------- 7
2. Sun as the source of all our energy ---------- 7
3. Principle of work ---------- 7
4. Meaning of term resistance ---------- 7
5. Definition of energy ---------- 6
6. Unit of measurement of work the foot-pound ---------- 6
7. Producing motion, depends upon overcoming resistance ---------- 6
8. Explanation of inertia ---------- 5

TABLE VII-H

Unit 8—Heating and Lighting

	Frequency
A. Heat	
1. Definition and illustration of convection in stoves	7
2. Explanation of burning	7
3. Construction and use of a fire extinguisher	7
4. Parts and principle of operation of the steam engine	6
5. Definition and illustration of conduction	6
6. Definition and illustration of radiation	6
7. The heating of the home by a hot water plant	6
8. The heating of the home by a steam plant	6
9. The heating of a home by a hot air plant	6
10. Common fuels and their relative importance	6
11. Story of the formation of coal	5
12. The heating of the home by the fireplace	5
13. Heat is a form of energy	5
14. The thermos bottle	4
B. Light	
(a) Nature	
1. Light travels in a straight line	6
2. Definition of a transparent body	5
3. Definition of a translucent body	5
4. Definition of an opaque body	5
(b) Color	
1. Sunlight is composed of seven colors (spectrum)	5
2. How the color of objects is determined	5
3. Meaning of terms white and black	5
4. Different colors have different wave lengths	4
(c) Eye	
1. Explanation of a lens	6
2. Structure of the human eye	6
3. How to take care of the eyes	6
4. How the sensation of sight is produced	5
5. How to test astigmatism	5
6. Make up and operation of a simple camera	4
(d) Home lighting	
1. Sun as the source of natural light	7
2. Construction and operation of incandescent lamp	7
3. Thomas Edison invented the incandescent lamp	7
4. The kerosene lamp	7

5. Burning of gas as a source of artificial light	6
6. Burning of a candle	6
7. Gas mantle burner	6
8. Importance of proper lighting in the home	6
9. Indirect lighting in the home	6
10. How to select wall paper for a room	5
11. Direct lighting systems	5
12. Semi-direct lighting systems	5
13. Advantages and disadvantages of various types of lighting systems	5
14. The candle power as a unit of measurement of light	5
15. The open flame gas burner	5

TABLE VII-I

Unit 9—Magnetism, Electricity, and Communication

A. Magnetism	Frequency
1. Nature of the lines of force about a magnet	7
2. Polarity of magnets	7
3. Laws of magnetism	6
4. The compass as a magnet	6
B. Static Electricity	
1. Electron theory of matter	5
2. Difference between static and current electricity	4
3. Static electricity is produced by friction	4
4. Lighting as a discharge of static electricity	4
C. Current Electricity	
1. Production of electricity by chemical action	7
2. How to make an electromagnet	7
3. Construction and operation of an electric doorbell	7
4. Construction and operation of a telegraph set	7
5. Electric fuse and its uses	7
6. Telephone transmitter and receiver	7
7. Production of electricity by cutting the lines of force of a magnetic field	7
8. Operation of the dynamo	7
9. Operation of a simple electric motor	6
10. A magnetic field is associated with an electric current	6
11. Morse invented the telegraph instrument	6
12. High resistance conductors develop a large amount of heat	6
13. Difference between direct and alternating currents	6
14. How to read an electric meter	6

15. Composition of the dry cell ---------- 5
16. Telephone invented by Bell ---------- 5
17. Construction and use of transformers ---------- 5
18. Definition of volt ---------- 5
19. Definition of ampere ---------- 5
20. Definition of kilowatt hour ---------- 5
21. Application of electric motor in vacuum cleaner ---------- 4
22. Explanation of electric iron ---------- 4
23. Explanation of electric heaters ---------- 4
24. How to connect cells in series or parallel and the effects produced -- 4
25. Use of nichrome in electric heating devices ---------- 4
26. Composition of lead storage battery ---------- 4

D. Radio

1. General principles underlying radio ----------6
2. How radio waves are produced ---------- 6
3. Determination of length of waves ---------- 5
4. Properties of electro-magnetic waves ---------- 5
5. Composition and operation of three-element vacuum tube --------- 5
6. Use of three-element tube as a detector ---------- 5
7. How to make a simple one tube receiver ---------- 5
8. Various parts of simple radio receivers ---------- 5
9. How to make a simple crystal set ---------- 4

TABLE VII-J

Unit 10—Travel and Transportation

A. Methods of Travel and Transportation — Frequency

1. Explanation of the following strokes in a gas engine ---------- 7
   (a) Intake
   (b) Compression
   (c) Power stroke
   (d) Exhaust
2. Automobile as an application of the gas engine ---------- 7
3. Construction and operation of the steam engine ---------- 7
4. Application of the steam engine in the locomotive ---------- 6
5. Conditions under which a body floats or sinks ---------- 6
6. Use of airplane for travel and transportation ---------- 6
7. Principles underlying operation of the submarine ---------- 5
8. Principles of operation of an airship ---------- 5
9. Archimedes' principle ---------- 5
10. Application of steam engine in steamships ---------- 5

11. Explanation of parts of an automobile.
    (a) Ignition system ---------- 4
    (b) Carburetor ---------- 4
    (c) Cooling system ---------- 5
    (d) Clutch and gears ---------- 4
    (e) Differential ---------- 4
    (f) Lubrication ---------- 3
12. Importance of automobiles in our complex economic system ---------- 5
13. Application of electric motors in trolley cars and locomotives ---------- 5
14. Principles underlying the flying of heavier than air machines (airplanes) ---------- 5
15. Airplane invented by Wright Brothers ---------- 4

There is a considerable amount of instructional material being developed in some of the later textbooks of general science about "Clothing" and "Home building and Construction." The content of this material is given in Tables VII-K and VII-L to show the trend in this direction. With the exception of some of the facts about clothing (marked by an asterisk (*)) it should not be considered a part of the nucleus of the general science course as it does not appear in a majority of the texts.

TABLE VII-K

Unit 11—Clothing

1. Coolest clothing in summer is linen.*
2. Linen is best conductor of heat.*
3. Warmest clothing is made from wool.*
4. Wool is the poorest conductor of hear.*
5. Temperature of a healthy person is 98.6° F. regardless of climatic conditions.*
6. The warmth of fur and wool clothing is due to enclosed air.
7. Loosely woven clothing is cooler.
8. Dark colored clothes are warmer because they are better absorbers of heat.*
9. White clothes are cooler because they reflect more heat.
10. To be familiar with different textiles fibers and sources.
11. How soap cleanses.
12. Know good methods of removing stains from clothing.
    (a) Solution.

(b) Absorption (such as blotting paper).
(c) Bleaching (such as chlorine or bleaching powder).
(d) Neutralization (heating with an alkali or an acid).

13. How fabrics are dyed.
14. How to prevent clothing from being attacked by moths.
15. The life history of the moth.
16. How to identify cotton, linen, woolen or silk goods by use of tests.
17. How to distinguish between real and artificial silk.
18. How to test mixed goods.
19. How to test for fast colors.
20. How to bleach cloth.
27. Human body loses heat by radiation, conduction, and evaporation.
22. Wool, silk, and fur are animal fibers.
23. Linen is made from flax plant.
24. The life history of the silk worm.
25. Type of clothing worn depends upon the climate.
26. Type of clothing worn depends on fashions.
27. Human body loses heat by radiation, conduction, and evaporation.
28. How fabrics may be adulterated.
29. Purpose of clothing.
30. Air is a poor conductor of heat.
31. Classification of fibers into vegetable and animal.

TABLE VII-L

Unit 12—Home and Building Construction

1. To know the most common American woods.
2. The causes of decay of wood.
3. How to prevent decay of wood.
4. The different materials used in constructing homes and other buildings.
   (a) Lime products
   (b) Wood products
   (c) Glass products
   (d) Building stone
   (e) Metal products
   (f) Clay products
   (g) Cement products
5. The advantages of each type of building material.
6. The ideal home should afford plenty of fresh air.
7. The ideal home should afford plenty of sunlight.

8. The ideal home should be free of offensive odors.
9. The ideal home should be conveniently placed.
10. The ideal home has attractive surroundings.
11. The ideal home has good drainage and water supply.
12. The ideal home is built of fire-proof materials.
13. The dangers of gas and electricity in the home.
14. To be familiar with common hard and soft woods.
15. The "grain" of wood is formed by the annual rings.
16. To estimate approximately the age of a tree by its annual rings.
17. The importance of a good foundation to a house.
18. The requirements of a good cellar are dryness and good drainage.
19. Cement is made by heating together limestone, clay and sand.
20. The walls of a foundation must remain plumb.
21. Characteristics of hardwood and softwood floors.
22. Roof of a house should be water proof and fire proof.
23. Roof of a house should be a poor conductor of heat.
24. To know some of the common roofing materials.
25. How bricks are made.
26. Concrete is a mixture of cement, gravel, crushed stone and water.
27. Reinforced concrete contains metal rods or wire mesh.
28. Advantages of a stucco house.
29. The common building stones are:
    (a) Granite
    (b) Sandstone
    (c) Limestone
    (d) Marble
    (e) Slate
30. Structural steel used in building large buildings.
31. Hardwoods are woods from broad leaved trees.
32. Softwoods are woods from trees with needle-like or scale-like leaves.
33. Knots are caused by a branch leaving the stem.
34. Nature of primitive homes.
35. Nature of tools used by men in past ages.
36. Difference between physical and chemical properties of materials.
37. Wood is the most commonly used building material.
38. Four processes in preparing wood for building purposes.
    (a) Cutting and logging trees.
    (b) Sawing the logs.
    (c) Seasoning the lumber.
    (d) Finishing the boards.
39. Grain in lumber depends upon the growth of tree and method of sawing.
40. The nature of the medullary rays in wood.
41. How tiles are made.

42. How pottery is made.
43. How lime is made.
44. Some uses of lime.
45. How stucco is made.
46. How mortar is made.
47. How plaster is made.
48. How glass is made.
49. How iron is freed from iron ore.
50. The meaning of the terms hard wood and soft wood.

CHAPTER IV

THE EXTENT OF MASTERY OF THE INSTRUCTIONAL MATERIAL OF GENERAL SCIENCE

To provide a knowledge of those facts, principles, and applications of science that will give a better understanding and lead to a better control of one's environment is considered one of the important objectives of high school general science. The extent to which learning in general science will function in thinking about the conditions of one's environment depends in a large measure upon the abundance of ideas, facts, and principles of science that one possesses. It would be contrary to the principles of modern psychology to suppose that one will reason correctly about the heavens, the electrical applications in the home, or the causes of changes in the weather without having an essential stock of facts about these things. Gates[1] says, "To learn how to learn, and *to learn a great deal*[2], are probably the two most important aids to efficient reasoning."

It is true that a mere accumulation of facts will not guarantee clear thinking. It is a well established psychological principle that the extent to which knowledge learned in the classroom will function in life situations depends very largely upon the identical elements in the two situations and the extent to which these elements are recognized by the learner. A mere memorization of the facts of general science can hardly be justified on any grounds. At the same time it is also true that correct thinking about our environment cannot go on without a knowledge of certain facts and principles of science.

The core of general science instruction determined by the textbook analysis discussed in Chapter III represents the prevailing view as

1 Gates A. I. *Psychology for Students of Education* p. 338.

2 Italics are not in the original.

to what pupils should learn, to have such a working basis of knowledge for interpreting their environment.

But the instructional material to be used in a general science class must be selected not only in terms of the environment in which we are living but also with reference to the capacities and abilities of the pupils. The difficulty of the subject matter for ninth grade classes must be carefully adjusted to the capacities of ninth grade pupils. It should contain instructional material difficult enough to challenge the best abilities of the group but at the same time not so difficult as to cause many failures. Judging from scientific investigations such as the one made by Powers in high school chemistry[3] the tendency in the past has been to incorporate too much difficult material in high school science courses rather than too easy material.

To determine how well the general science course is functioning, the next step then is to determine how much of this subject matter material pupils do really learn. Whether this knowledge functions in their thinking depends upon how it is learned. This phase of learning is a problem in itself and lies outside the scope of this investigation. This study is confined to the problem, what do pupils know about general science topics at the end of a year's instruction?

In this chapter are presented the results of an extensive testing program carried on to determine the degree of mastery of the instructional material of general science. Let us consider first the methods employed in this study. Objective tests were constructed for each of the units of subject matter determined by the textbook analysis presented and described in Chapter III. Questions of the multiple choice type were used almost exclusively. Twelve completion statements were employed where a multiple choice question could not be satisfactorily made. Each item tested by a completion statement is starred in the tables that follow. The directions to students taking the tests and a few samples of the questions are given below.

3 Powers, S. R. *A Diagnostic Study of Subject Matter in High School Chemistry*. Bureau of Publications, Teachers College, Columbia University.

DIRECTIONS TO STUDENTS

This is a test of your knowledge of science. Test items similar to the following illustration are on the following pages.

Illustration:

(a) The steamboat was invented by

Edison Ford Fulton Franklin Marconi

In the illustration the name of Fulton is underscored because it makes the statement true. In like manner you are to underline the word or group of words which most satisfactorily completes each statement on the following pages.

(b) In a few of the statements a part of the sentence is left blank. You are to fill each blank with a word so as to make a true statement.

SAMPLE TEST ITEMS

1. The sun is a

planet star comet meteor satellite

2. Water is an

element mixture solution chemical compound hybrid

3. Mosquitoes lay their eggs on

grass mud garbage stagnant water manure

4. Like poles of magnets _____ and unlike poles will _____ each other.

Finally these tests were administered to approximately 400 pupils of eight selected high schools[4], who were just completing one year of study in ninth grade general science. A table showing how these tests were distributed among the schools is given in the appendix. The schools were selected because of their availability and because only well trained and experienced teachers are employed in them. Since our problem here is to test the subject matter of general science rather than to determine norms of achievement it is important to

4 The following high schools cooperated in the testing program:
South Division High School, Milwaukee, Wisconsin
North Division High School, Milwaukee, Wisconsin
West Division High School, Milwaukee, Wisconsin
Washington High School, Milwaukee, Wisconsin
Sheboygan High School, Sheboygan, Wisconsin
West Allis High School, West Allis, Wisconsin
Grafton High School, Grafton, Wisconsin
Shorewood High School, Shorewood, Wisconsin

know whether the instructional material was properly presented to the pupils. To the extent that a college training and years of teaching experience insure good teaching it can be assumed that this has been the case.

The tests were scored and the total number of correct responses for each item of each test was counted. From these data the percentage of students that answered each item correctly was computed. For example, 194 of 366 pupils answered the test item, "Marble is an example of a metamorphic rock," correctly. The per cent correctness of this item then is $\frac{194}{366}$ or 53.0 per cent. In a similar manner the percentage correctness of every test item was calculated. It is quite likely that a small percentage of correct responses on each of the test questions was due to guessing. Since students of educational measurements have not yet devised a technique of correcting for guessing on multiple choice tests, the raw percentages are given.

The question can be appropriately raised at this time as to whether the percentage of students that do a task correctly is a measure of the difficulty of the instructional material. Too many variable factors were operating to conclude such a relationship from the data presented in this study. Methods of instruction, effectiveness of instruction, drill, and other factors would have their effect on the number of students that answer a question correctly. However, the testing was carried on in schools in which only well trained and experienced teachers are employed. It should also be kept in mind that only that subject matter which commonly occurs in general science textbooks was included in the tests and that all of the schools that cooperated in the testing program were using one or more of the texts that were used in the textbook analysis upon which the tests are based.

It was thought that there might be a relationship between the percentage of mastery of items of subject matter and the number of textbooks in which they appear. The mean percentages of mastery of items appearing in seven texts, six texts, five texts, and four texts were determined but no significant differences were found. For example the mean percentage of mastery of items of subject matter appearing in five texts was only one per cent less than the mean per-

centage of mastery of items appearing in seven texts for a combination of the items of two units.

Our interest now will be to examine the extent of mastery of the instructional materials of the various units of general science. All of the units presented in the textbook analysis in Chapter III with the exception of the units on Clothing and Home and Building Materials were included in the testing. These were not included because they are not, as yet, a part of the nucleus of the general science course. The same unit headings are used here as were used in Chapter III.

Table VIII-A gives the percentage of correctness for each item of subject matter of the unit Atmosphere and Weather that was tested.

Several phases of the unit Atmosphere and Weather are not well understood. The chemistry of air seems quite difficult for ninth grade pupils. It occasioned some surprise to find that only about 25 per cent of the pupils at the end of their course in general science could distinguish between physical and chemical changes. Seventy per cent of them were familiar with the lime water test for carbon dioxide while only 37 per cent knew that carbon dioxide is a non-poisonous gas. One would naturally think that the chemical test for carbon dioxide is more difficult than learning that carbon dioxide is not poisonous. Inspection of the pupil responses to the test items showed that the pupils quite often confuse carbon dioxide with the dangerous and very poisonous carbon monoxide gas. Of the topic weather, classification and definition of clouds is one of the most difficult phases. In many general science textbooks clouds are defined and excellent photographs of the various types presented. Nevertheless about 80 per cent of the pupils fail to master cloud classification. It certainly is open to debate as to whether this topic of clouds is of much value in general science. Only 40 per cent of the pupils know that it is excessive humidity that produces the discomforting effects that people experience in a poorly ventilated room. An inspection of this question revealed the fact that nearly all of the remaining 60 per cent of the group thought an insufficient supply of oxygen or a poisonous effect of carbon dioxide were the causes. This seems to indicate that some of the fundamental underlying principles

of ventilation are not being mastered by pupils studying general science.

TABLE VIII-A

Unit 1—Atmosphere and Weather

	Per cent Correct
1. The barometer is an instrument used to measure air pressure	89.3
2. The force of air pressure causes water to rise from the well into a lift pump when the piston is raised	88.6
3. The term humidity refers to moisture in the air	87.5
4. Sound is produced by vibrating matter	82.0
5. When a glowing splint is put into a bottle and stoppered it soon goes out because of an insufficient oxygen supply	80.2
6. Mountain ranges are the chief cause of unequal rainfall in different parts of the United States	79.5
7. For comfort and health the temperature of a room should be approximately 68° F	77.7
8. The phonograph is a device that reproduces sound	75.5
9. Condensation is changing from the gaseous to the liquid state of matter	74.4
10. Heating causes gases to expand	72.2
11. The phonograph was invented by Edison	72.2
12. When carbon dioxide is passed through lime water the liquid becomes milky	70.4
13. The aneroid barometer is used by aviators to determine their altitude	68.9
14. The pitch of sound depends upon the number of vibrations per second	67.4
15. The cooling effect noticed when a person perspiring freely is exposed to a draft of air is caused by rapid evaporation of the perspiration	67.4
16. Air pressure at sea level is about 15 pounds per square inch	64.6
17. The difference between the readings of a dry bulb and a wet bulb thermometer at the same room temperature gives an indication of the relative humidity	63.0
18. The source of sound from a piano is vibrating strings	63.0
19. The changing from the liquid to the gaseous state of matter is called evaporation	62.3
20. When a definite quantity of air contains all the moisture it can hold it is saturated	62.0

21. The prevailing winds of the U. S. move across the continent from west to east ---------- 60.5
22. A rising barometric (air) pressure indicates the approach of clear weather ---------- 59.6
23. Sound is carried by air waves ---------- 58.9
24. Molecules are made up of two or more particles called atoms ---- 58.2
25. Bodily temperature is in part regulated by evaporation of perspiration ---------- 58.2
26. Fog is water vapor condensed around dust particles near the surface of the earth ---------- 56.2
27. Moisture which condenses in the air at a temperature below 32° F forms snow ---------- 55.8
28. A pump which removes air from a container is called an exhaust pump ---------- 55.4
29. The velocity of sound is less than the velocity of light ---------- 53.3
30. A falling barometric (air) pressure indicates an approaching storm 52.9
31. Air pressure at sea level will support a column of mercury 30 inches high ---------- 52.9
32. Heat from a hot air furnace is distributed throughout a house mainly by convection ---------- 52.9
33. The sensation of hearing is felt through the auditory nerve ------ 51.4
34. Zinc, mercury, hydrogen, and carbon are chemical elements ------ 51.4
35. Wood burning and iron rusting are examples of oxidation ------ 48.9
36. The prevailing winds in the temperate zones of the earth are called westerlies ---------- 48.1
37. The first mercury barometer was made by Torricelli ---------- 43.8
38. When an empty drinking glass is inverted and pushed under water it remains practically full of air ---------- 43.8
39. Raindrops which are carried to high altitudes by upward currents of air frequently fall to the earth as hail ---------- 42.4
40. A clarinet is a musical instrument that has for its source of sound a vibrating reed ---------- 42.0
41. The automobile tire and air-brake make use of compressed air ---- 40.8
42. The discomfort in a crowded room is due mainly to excessive humidity ---------- 40.1
43. A substance that has molecules made up of two or more kinds of atoms is called a chemical compound ---------- 39.9
44. Carbon dioxide is heavier than air ---------- 39.6
45. Liquids, solids, and gases are the three states of matter ---------- 38.6*
46. A spiral destructive storm of small area is called a tornado ------ 37.6
47. Carbon dioxide is a non-poisonous gas ---------- 37.6
48. The ratio of nitrogen to oxygen in the air is approximately 4 to 1 36.5
49. The speed of sound in air is about 1100 feet per second -------- 34.7
50. Lines drawn on a weather map representing places of equal temper-

ature are called isotherms	34.3
51. A bicycle pump is a compression pump	34.3
52. A spiral inward movement of air, often a thousand miles in diameter moving slowly across the U. S. in an easterly direction is called a cyclone	33.6
53. Identification and definition of cirrus clouds	33.3
54. A pump used to force air into a container is called a compression pump	33.3
55. An anti-cyclone is usually accompanied by cool and clear weather	32.5
56. Condensation of moisture around dust particles in the air forms clouds	31.6
57. Nitrogen in the atmosphere dilutes the oxygen	30.9
58. Oxygen is made in the laboratory by heating potassium chlorate	30.2
59. In the United States a southeast wind is usually accompanied by cloudy weather and rain	28.8
60. Wood being changed to sawdust is an example of a physical change	28.1
61. A relative humidity of approximately 50 is desirable indoors	27.8
62. Sound travels most rapidly through solids	27.0
63. Nitrogen and oxygen are the two gases present in the air in largest quantities	26.6
64. How to identify nimbus clouds	23.4
65. Carbon dioxide can be made in the laboratory by treating marble with hydrochloric acid	23.0
66. Water and carbon dioxide are the two substances formed when a candle burns	21.9
67. Coal burning is an example of a chemical change	21.0
68. An acid and soda are the chemicals used in a common fire extinguisher	19.7
69. How to identify cumulus clouds	17.0
70. Air is a mixture of compounds and elements	15.6
71. Potassium chlorate and manganese dioxide are mixed and heated in the preparation of oxygen.	10.2

TABLE VIII-B

Unit 2—Water, Water Supplies, and Sewage Disposal

	Per cent Correct
1. Water can be made safe for drinking purposes in the home by boiling it	89.1

2. Living organisms in water may be killed by boiling ---------- 87.7
3. Steam is used in a steam engine because expanding steam exerts pressure ---------- 84.2
4. The boiling point of water is 212° F ---------- 82.5
5. The freezing point of water is 32° F ---------- 81.0
6. The freezing point of water is 0° C ---------- 79.8
7. Soft water is water which does not contain dissolved minerals ---- 79.5
8. The boiling point of water is 100° C ---------- 75.0
9. Melting ice takes in heat ---------- 72.0*
10. To prevent sewer gases from entering the house, drain pipes are connected with water traps ---------- 71.9
11. Ice floats because it is lighter than water ---------- 70.6
12. Water is composed of the two chemical elements hydrogen and oxygen ---------- 70.2
13. The most dependable source of water is deep driven wells ------- 70.2
14. Water is a good solvent ---------- 68.5
15. Wells from which water flows by its own pressure are called artesian wells ---------- 67.1
16. The most satisfactory disposition of sewage is to empty it into septic tanks ---------- 66.2
17. Temporary hardness of water can be removed by boiling -------- 65.4
18. Filtration and the addition of chemicals are two methods employed by cities to purify their water supply ---------- 63.6
19. Typhoid fever is a disease commonly spread through drinking water 63.2
20. When water freezes its volume increases ---------- 63.0
21. The separation of dissolved solids from liquids by evaporation and condensation is called distillation---------- 61.9
22. Where no water pumps are used the pressure of the water in the water pipes of our homes is determined primarily by the height of the source of the supply ---------- 60.2
23. Permanent hardness of water is removed by adding chemicals ---- 54.0
24. Septic tanks and contact filter beds provide two safe methods of sewage disposal ---------- 47.6
25. As water changes to steam its volume increases ---------- 44.0
26. The most dangerous impurity in water is usually bacteria -------- 42.4
27. Convection currents are set up in water when it is heated -------- 39.3
28. In a hot water heating system the heat is transfered from the boiler to the radiators mainly by convection currents ---------- 34.9
29. Artificial refrigeration plants are applications of the scientific principle that evaporating liquids take in heat ---------- 34.8*
30. Water may exist as a solid, a liquid, or a gas ---------- 34.6*
31. During the process of evaporation heat is taken in ---------- 33.7
32. Reducing pressure on water lowers the boiling point, while increas-

	ing pressure on water raises the boiling point	29.1*
33.	Water is a chemical compound	26.6
34.	A cubic foot of water weighs about 62.4 lbs.	25.0
35.	Water can be decomposed into its elements by electrolysis	23.5
36.	The freezing temperature of water and the melting temperature of ice are the same	20.7
37.	A cubic centimeter of water weighs one gram	14.8
38.	Water contracts on cooling until it reaches 4° C	12.4
39.	Water has its greatest density at 4° C	12.4
40.	Permanent hardness of water is usually caused by dissolved calcium and magnesium salts	12.1
41.	One division on the Fahrenheit thermometer is equal to five-ninths divisions of the Centigrade scale	12.0*
42.	As a quantity of water changes from liquid to ice its temperature remains constant	10.8

In Table VIII-B the extent of mastery of the instructional material of the unit, Water, Water Supplies, and Sewage Disposal is shown. The practical phases of this unit such as water purification, sewage disposal, and thermometers seem to be fairly well understood. It is interesting to note that while 70 per cent of the students knew that water is composed of the two elements hydrogen and oxygen only 26 per cent of them identified it as a chemical compound. This seems to indicate quite clearly that the difference between chemical elements and compounds is either too difficult for the majority of ninth grade pupils or that the subject is not adequately presented in textbooks or by teachers of general science. While 63 per cent know that the volume of a given weight of water increases when it freezes, only 12.4 per cent know that water begins expanding four degrees before it reaches the freezing point on the Centigrade scale. In fact the irregularities in the reaction of water to changes in temperature seem to be the most difficult phase of this unit. The scientific principles underlying artificial refrigeration are also not well understood.

TABLE VIII-C

Unit 3—The Earth and Other Heavenly Bodies

	Per cent Correct
1. The earth is a planet	90.7
2. The telescope is an instrument through which stars are studied	90.0
3. The distance from the earth to the sun is approximately 93,000,000 miles	89.1
4. The surface of the moon is covered with deep craters	87.7
5. The sun is the source of our energy on the earth	87.6
6. "Shooting stars" are properly called meteors	87.1
7. Gravitation is the force which holds the heavenly bodies in their courses	83.5
8. The idea that the heavenly bodies exert evil influences on the lives of people is untrue	83.0
9. The sun, planets, and their satellities together form the solar system	82.3
10. The passing of the moon directly between the sun and earth causes an eclipse of the sun	82.0
11. Groups of stars that form conspicuous figures in the sky are known as constellations	80.8
12. The diameter of the moon is less than that of the earth	80.2
13. The Big Dipper is a constellation	80.0
14. The sun is the center of our solar system	78.0
15. The moon causes tides	75.5
16. Day and night are caused by the earth's rotation on its axis	75.2
17. Light travels 186,000 miles per second	75.0
18. Saturn is the only planet with a system of rings around it	72.7
19. The sun is a star	71.0
20. The North Pole of the earth points toward the North Star	68.1
21. There are eight major planets	68.0
22. The stars are classified according to brightness into magnitudes	68.0
23. Mercury is the nearest planet to the sun	67.5
24. The North Star can be located by two stars in the Big Dipper	64.0
25. The telescope was invented by Galileo	63.7
26. The inclination of the earth on its axis causes the change of seasons	61.3
27. The phases of the moon are caused by its movement around the earth	61.0
28. Jupiter is the largest planet	58.8
29. The instrument used to determine the elements in the sun is called a spectroscope	56.0

30. There are stars larger than our sun ---------- 54.1
31. Equinoxes are periods of the year when days and nights are equal 48.3
32. The visibility of the planets and our moon is due to reflected light from the sun ---------- 36.2
33. Mercury is the smallest planet ---------- 35.9
34. The planet Venus most nearly resembles our earth ---------- 11.4

Table VIII-C gives the percentage of correct responses for items of subject matter of the unit, The Earth and Other Heavenly Bodies. The subject matter of general science tested by these items is acquired quite well by the pupils. With a few exceptions the astronomical material contained in this unit seems quite well adapted to the abilities and interests of ninth grade pupils. Only 11.4 per cent of the pupils know however that the planet Venus resembles the earth more closely than any other planets. Most of the pupils name the planet Mars. This may be due to the fact that when the habitability of other planets is discussed, the planet Mars is quite frequently mentioned. The whole question of life on other planets is so involved in a clear understanding of a large number of facts and inferences about conditions on the planets that unless considerable careful attention is given to them superficial conclusions will be reached by the pupils. The following statement, a quotation from Abbot[5], is given because it is succinct and definite on this point. "Of all the planets, Venus is most like the earth. It is the one which comes nearest to us, excepting our moon and some of the little bodies called 'asteroids' or minor planets. Eight-tenths as massive, more highly reflecting, and two-thirds as far from the sun as the earth, Venus seems more fit on many accounts than any other of the planets to support life similar to ours."

[5]Abbot, C. G. The Earth and the Stars, page 72.

TABLE VIII-D

Unit 4—Rocks and Soil

	Per cent correct
1. Rocks formed of sediment deposited by water are called sedimentary rock	94.0
2. The supplying of water to the soil artificially is called irrigation	93.1
3. Glaciers consist largely of ice	90.9
4. Clay soil becomes sticky after a rain	90.0
5. Swampy lands have been reclaimed by use of artificial drainage	87.4
6. The wearing away of soil and rock is called erosion	85.0
7. The planting of different crops in the same field on successive years is called rotation of crops	80.0
8. The United States government has undertaken some irrigation projects in the southwest region of the United States	78.9
9. Our best all around fertilizer is probably manure	74.8
10. Limestone is a sedimentary rock	74.3
11. The water used for irrigation of land is usually supplied from dams	68.6
12. The level at which water is beneath the surface of the soil is called the water table line	66.9
13. Humus is composed chiefly of organic matter	64.2
14. Capillary action causes water in the soil to rise	60.3
15. Igneous rocks are formed from hot molten matter	58.7
16. Soils are classified according to size of particles	58.5
17. Wind is the most common cause of erosion in desert regions	58.5
18. Granite is an example of an igneous rock	54.6
19. Marble is an example of a metamorphic rock	53.0
20. Metamorphic rocks are formed by the combined action of heat and pressure	52.4
21. Fertility of soils depends upon mineral content	52.0
22. Water is an agent of erosion when it freezes	46.5
23. Vegetation protects soil from erosion	46.1
24. Finely divided soil holds water best	42.0
25. Soil to be fertile must contain phosphorus	40.4
26. Legumes are plants on which bacteria grow that take nitrogen from the air	34.9
27. An acid condition of the soil can be corrected by use of lime	33.3
28. Alluvium (soil) is built up from deposits by rivers	22.6
29. Clover and bean plants are leguminous plants	16.9

Table VIII-D shows the extent of mastery of the instructional material in the unit, Rocks and Soil. Factors relating to soil fertility are not mastered in this work. The relation of leguminous plants to nitrogen supply in the soil is an especially difficult phase. Thirty four and nine tenth per cent of the group knew that legumes are plants on which certain bacteria grow but only 16.9 per cent of the group could identify clover and bean plants as legumes. This topic is treated in nearly all textbooks in general science and the following is a typical description: "As an element, nitrogen[6] is the colorless gas which makes up four-fifths of the air. The only living things that can use the nitrogen from the air are certain low forms of plant life which grow in the soil. The most important of these are certain bacteria which show a decided preference as to plants they will live with; choosing only plants of the legume family—clover, peas, beans, alfalfa. On the roots of these they grow in little nodules or tubercles, from a pinhead to a pea in size. These nodules were once thought to be a root disease, but they are now known to be the greatest blessing of agriculture, because they are rich in nitrogen; and the element is the one that is most lacking in soils. The roots of corn, oats, grass, cotton, etc., never have these nodules upon them; they must depend upon the nitrogen stored in the soil by previous crops of legumes or supplied by the farmer in manure or artificial fertilizer." This statement seems about as elementary as this topic could be made. In other textbooks of general science similar statements appear, but it is evident that this topic is not functioning very well.

TABLE VIII-E

Unit 5—Food and Nutrition

	Per cent correct
1. Foods that will make a grease spot on paper always contain fat	95.2
2. The calorie is the unit of measurement of energy value of foods	91.7

[6]Webb and Didcoct, Early Steps in Science, page 454.

3. Blood is forced through the body by the heart ---------- 90.9
4. Saliva is the digestive juice secreted in the mouth ---------- 90.5
5. Heating milk to a temperature of from 140° F to 155° F for a period of about 20 minutes is called pasteurization ---------- 89.3
6. Alcohol is not considered a satisfactory food because it injures the nervous system ---------- 87.8
7. Milk is almost a perfect food ---------- 87.2
8. Digestion is the process of changing food from a solid to a liquid form in the body ---------- 82.5
9. Pasteurization is a satisfactory method of safeguarding milk from disease germs ---------- 82.1
10. A balanced diet is necessary for good health ---------- 78.9
11. The calorific value of foods is determined by means of a calorimeter 77.7
12. Tubes which carry blood away from the heart are called arteries --- 75.2
13. About two-thirds of the weight of the human body consists of water 75.2
14. Sugar and starch are carbohydrates ---------- 73.2
15. Impure blood is purified in the lungs ---------- 73.2
16. Cooking food makes it more digestible ---------- 71.1
17. Foods that build up or repair tissues contain proteins ---------- 70.1
18. Foods that aid in building bone and teeth contain mineral matter -- 69.4
19. Gastric juice is secreted in the stomach ---------- 68.5
20. Leafy vegetables should be eaten because they usually contain vitamines ---------- 67.0
21. Coffee and tea are stimulants ---------- 67.0
22. Cocoa is more nutritious than coffee or tea ---------- 65.0
23. Digestion of starch begins in the mouth ---------- 64.6
24. Organic foods are formed by living things ---------- 62.9
25. Diseases such as scurvy and beri-beri are due to lack of vitamines in diet ---------- 57.5
26. The largest percentage of our diet should consist of carbohydrates 56.3
27. Starch in foods turns blue in presence of iodine ---------- 56.0
28. Vitamines are classified by letters of the alphabet ---------- 48.9
29. Food is manufactured by green plants ---------- 45.6
30. Foods should be sterilized before canning ---------- 44.8
31. Certified milk means that the milk has been bottled under sanitary conditions ---------- 43.6
32. Beans are one of our least expensive protein foods ---------- 39.7
33. Beefsteak is rich in proteins ---------- 37.0
34. Enzymes in the human body cause chemical changes during digestion 36.8
35. Foods which turn yellow when treated with diluted nitric acid contain proteins ---------- 35.0
36. Eggs and meat are rich in proteins ---------- 34.5
37. Absorption of digested food takes place mostly in the small in-

testines	34.5
38. Heat and energy are furnished to the body mostly by carbohydrates and fats	34.1
39. Potatoes contain a high percentage of carbohydrates	34.1
40. Fat has the largest energy value of all foods	27.9
41. Fehling's solution is commonly used to test for the presence of sugar in foods	27.7
42. Nitrogen is found only in protein foods	27.0
43. There is about 4 per cent of butter fat in milk as it comes from the cow	25.2
44. Eggs and spinach are foods that contain iron	24.4
45. Spinach and tomatoes are rich in vitamines	21.6
46. Nuts are a good substitute for meat	16.9
47. The enzyme ptyalin is in saliva	12.1
48. Fats and carbohydrates are made up of the elements, carbon, oxygen, and hydrogen	11.9

Table VIII-E shows the difficulties involved in the unit, Foods and Nutrition. The chemistry of foods is not mastered by ninth grade general science pupils. Only one chemical food test was known by more than 50 per cent of the group; the iodine test for starch by 56 per cent. The most disturbing feature of this unit of work, however, is the failure of the pupils after a year's study of general science to recognize common foods rich in various food nutrients. Although about 80 per cent recognized the need of a balanced diet for good health only 34 per cent identified potatoes as a rich carbohydrate food, 35 percent identified eggs and meat as rich protein foods, 24 per cent identified eggs and spinach as foods that contain iron and but 21 per cent recognized spinach and tomatoes as good vitamine containing foods. Simply to know that a balanced diet is necessary for good health may have some value but to make this generalization effective in every day life one must also have a knowledge of the principal nutrients in common foods, and furthermore must know what proportions of the various food nutrients make a balanced diet. Only 56 per cent knew that the largest percentage of our diet should consist of carbohydrates.

TABLE VIII-F

Unit 6—Life on the Earth

	Per cent Correct
1. The process of introducing antitoxins into the blood is called vaccination	86.3
2. The best way of getting rid of mosquitoes is to pour oil on their breeding places	84.0
3. The best method to use to get rid of flies is to destroy their breeding places	80.0
4. Mosquitoes lay their eggs on stagnant water	79.0
5. The study of all living things is called biology	78.5
6. The statement that "All life comes from life" is true	76.1
7. Flies lay their eggs in manure	75.3
8. The work of the white corpuscles in the blood is to destroy disease organisms	74.0
9. Soil water and minerals enter plants through the root-hairs	72.0
10. The continuance from generation to generation of similar traits in living things is called heredity	71.5
11. The aesophagus (gullet) is a part of the digestive system	67.3
12. The agent used in the treatment of diphtheria is antitoxin	65.0
13. Disease bacteria in the human body give off poisons called toxins	64.0
14. The tubes that carry impure blood to the heart are called veins	61.6
15. The green substance in the leaves of green plants is called chlorophyll	60.0
16. One-celled animals are called protozoa	54.8
17. There are four stages in the life history of the fly and the mosquito	53.7
18. Green plants manufacture food only in the presentce of light	51.0
19. The transfer of pollen from anther to stigma of flowers is called pollination	48.5
20. The larva of the fly is called a maggot	46.0
21. One of the functions of the root of a plant is to anchor it	46.0
22. An element commonly taken from the soil by plants is nitrogen	45.8
23. Anopheles is the genus of mosquitoes that carries malaria germs	43.8
24. The larva of a mosquito is called a wriggler	43.4
25. All of the living matter within a cell is called protoplasm	43.4
26. A person who does not contract a desease when exposed to the disease germs is said to be immune	42.0
27. The passing or diffusing of liquids through a membrane is called osmosis	41.0

28. The small openings through which carbon dioxide enters the leaves of plants are called stomata	41.0
29. The organs of reproduction of a plant are in the flowers	40.3
30. The embryo of a plant is contained in the seed	38.6
31. During the process of food manufacture in green plants oxygen is given off as a waste product	38.0
32. Food is manufactured by plants principally in the leaves	37.4
33. Bacteria are plants	32.0
34. The uniting of the sperm or male cell of a flower with the egg cell is called fertilization	32.0
35. The process by which green plants manufacture carbohydrates from water and carbon dioxide is called photosynthesis	31.0
36. Flowers which bear stamens only are called staminate flowers	31.0
37. The pollen of flowers is made by the stamen	25.0
38. Two other ways besides fertilization by which plants can be propagated are grafting and budding	24.3
39. The petals of flowers serve to attract insects	19.7
40. Plants that are hosts for bacteria which take free nitrogen from the air are called legumes	19.0

Table VIII-F shows the phases of the unit dealing with living things that are not mastered. Nearly all of the phases of the instructional material of this unit that are not mastered have to do with plants. Food manufacture in plants, reproduction, osmosis, pollination, and flower structure are topics that are not well learned.

TABLE VIII-G

Unit 7—Energy, Work, and Machines

	Per cent Correct
1. The point on which a lever rests and moves around is called the fulcrum	81.9
2. A combination of fixed and movable pulleys is used to raise a piano from the first floor to the tenth floor of a building	76.6
3. The resistance offered when the surface of one body is moved over the surface of another body is called friction	68.0
4. There are three classes of levers	60.0
5. The mechanical advantage of an inclined plane 12 feet long and 3 feet high is 4. (Problem)	58.6

6.	Turbines are used in power plants to run dynamos	57.9
7.	33,000 foot pounds of work per minute or 550 foot pounds of work per second is equivalent to one horse power	56.2
8.	A wheelbarrow is a second class lever	54.2
9.	If the length of the effort (power) arm of a lever is increased its efficiency will be increased	52.6
10.	Mud flying from a moving wheel and separation of cream from milk in a dairy separator are examples of centrifugal force	50.9
11.	A pair of scissors is a first class lever	49.9
12.	A boy weighing 120 pounds walking upstairs to a height of 10 feet does 1200 foot pounds of work. (Problem)	47.3
13.	The wheel and axle is a modified lever	43.4
14.	The foot-pound is a unit of measurement of work	43.0
15.	By the use of one movable pulley 200 pounds can be lifed by a force of approximately 100 pounds. (Problem)	39.9
16.	Energy is the capacity for doing work	39.4
17.	A moving train or automobile possesses kinetic energy	38.2
18.	Kinetic energy is energy of motion	37.5
19.	Energy may be transferred but not created or destroyed	37.5
20.	Rowing a boat with oars is an example of first class lever	36.9
21.	The tendency for a body at rest to remain at rest or a body in motion to remain in motion is called inertia	36.5
22.	A wedge is an inclined plane	36.1
23.	The horse power is a unit of measurement of rate of work	34.5
24.	A machine is a device that aids in overcoming resistance	33.5
25.	People standing in a moving train or street car are thrown forward when the train stops. This is due to inertia	32.2
26.	The efficiency of a machine is always less than 100 per cent	31.2
27.	Lifting jacks such as the automobile jack are applications of screw	25.6
28.	Automobiles skid oftentimes when turning a sharp curve due to inertia	18.0
29.	The ratio of the resistance overcome by a machine to the force applied is its mechanical advantage	10.0

The items in Table VIII-C test the pupil's knowledge of energy, work and machines. It is evident from an examination of these data that either this is a difficult unit of work or it is not well taught. Only ten items of the twenty-nine are answered correctly by more than 50 per cent of the group. The development of scientific concepts in the minds of pupils is claimed to be one of the most important functions of general science which makes it rather disturbing

to find that for the majority of the pupils completing the course in general science, their notions of machines, energy, and inertia are still naive. Efficiency and mechanical advantages of machines are understood by only a small percentage of the group.

TABLE VIII-H

Unit 8—Heating and Lighting

	Per cent Correct
A. Heat	
1. Temperature is measured by a thermometer	93.0
2. Heating causes most substances to expand	79.0
3. Heat from the sun reaches the earth by radiation	75.3
4. The transference of heat by movements of currents is called convection	69.4
5. When fuel burns the carbon of the fuel unites with oxygen	65.1
6. Heat can be transferred from one place to another by conduction, convection, and radiation	57.0*
7. The hot air furnace heats and ventilates at the same time	55.2
8. The principal substance in fuels is carbon	54.2
9. In a hot water heating plant the hot water pipe which leads to the radiators is attached to the hot water boiler at the top	44.0
10. A yellow gas flame is yellow because of the presence of unburned carbon particles	36.5
11. Houses with hot air furnaces are heated mainly by convection	35.1
12. A calorie is the amount of heat required to raise one gram of water one degree Centigrade	32.2
13. Radiation is the only method by which heat can pass through a vacuum	30.2
14. The calorie is a unit of measurement of heat	28.0
B. Light	
1. Our sun is the chief source of natural light	80.2
2. When reading or studying we should sit so that the light comes over our shoulder	79.0
3. Sunlight is the best kind of light to match colored goods by	72.3
4. Edison invented the incandescent lamp	70.3
5. The human eye operates on much the same principle as a camera	68.4
6. An object which absorbs all colors will appear black	67.1
7. The wall paper of a room should be light in color	67.1

8.	An object that reflects all colors will appear white	63.4
9.	A window-pane is a transparent substance	63.4
10.	Sunlight is composed of seven colors (spectrum)	62.5
11.	The color of an object is determined by the color of the light which it reflects	62.5
12.	A body that does not allow light to pass through it is said to be opaque	61.1
13.	The image formed by a lens is inverted	50.3
14.	When light passes from one medium to another, as from air to water, the rays of light will be refracted	48.6
15.	The blurring of images due to irregularities in the curvature of the eye ball is an eye defect called astigmatism	46.3
16.	The image of things we see fall on the sensitive part of the eye called the retina	42.4
17.	A body that permits light to pass through it, but through which objects cannot be seen, is said to be translucent	37.5
18.	The candle power is a unit of measurement of the intensity of light	34.5
19.	Light travels by waves in ether	31.0
20.	A person who is near sighted needs glasses with concave lenses	31.0
21.	The part of the human eye that forms images of objects that we see is called a lens	29.9
22.	Photography depends upon the chemical action begun in silver salts by light	29.0
23.	The color of light depends upon its wave length	14.8

The items of Table VIII-H test the pupil's knowledge of heat and light. The pupils do not have clear ideas about conduction, convection and radiation, the methods of heat transference. This is evidenced by the fact that but 35 per cent knew that heating with a hot air furnace is an application of convection and but 30 per cent knew that radiation is the only method by which heat can traverse a vacuum. In the topic of light the study of the human eye stands out as difficult. The parts of the human eye, the functions of these parts and eye defects are not being mastered. Only 31 per cent knew that light is a wave motion in ether and only 14.8 per cent knew that color of light depends upon its wave length. Light apparently is another phenomenon about which the pupils' notions at the end of their course in general science are still naive.

TABLE VIII-I

Unit 9—Magnetism, Electricity, and Communication

	Per cent Correct
1. The telephone was invented by Bell	92.6
2. A magnet will attract iron	80.0
3. A magnet has two poles	80.0
4. The cost of electricity used in the home is figured at a certain cost per kilowatt hour	76.9
5. Lightning is a discharge of static electricity	75.3
6. The incandescent (electric) lamp was invented by Edison	72.3
7. The two elements of a dry cell are carbon and zinc	71.2
8. A fuse is a device used in an electric circuit to prevent the lights or any other electrical appliances from being burned out by an overload of current	68.0
9. The electric vacuum cleaner is operated by an electric motor	67.1
10. The compass can be used in finding directions because the earth is a magnet	64.9
11. Morse was the inventor of the telegraph	64.9
12. Copper is a good conductor of electricity	64.9
13. Like poles of magnets repel, and unlike poles attract each other	58.0*
14. A transformer is a device used for increasing or decreasing the voltage of an alternating current	58.0
15. Two electrical appliances that depend upon the heating effect of electricity are the toaster and the incandescent lamp	57.0
16. An electro-magnet can be made by winding insulated wire on a core of soft iron	55.9
17. A current of electricity which pulsates back and forth is called alternating current	54.5
18. Static electricity is produced by friction	53.7
19. Heating by electricity is accomplished by means of a high resistance wire	51.2
20. Sulphuric acid is a chemical used in lead storage batteries	48.3
21. A dry cell produces electricity from chemical action	48.2
22. Radio waves travel 186,000 miles per second	46.0
23. The vibration of the diaphragm of a telephone receiver is produced by means of an electro-magnet	45.4
24. The ampere is the unit of measurement of current	43.3
25. Electric storage batteries are charged by means of direct current	42.4
26. A dynamo is a device which generates electricity by cutting the lines of force of a magnetic field	41.0

27. In the three element radio tube, electrons shoot off from the hot filament ---------- 41.0
28. When a number of dry cells are so arranged that a carbon is always connected to a zinc they are in series ---------- 40.3
29. A transformer that steps up the voltage of a current has more turns of wire on the secondary than the primary ---------- 38.6
30. When the grid of a radio tube is positive the electrons from the hot filament are repelled ---------- 37.5
31. The voltage of the B battery of a radio circuit is greater than the voltage of the A battery ---------- 33.7
32. The volt is the unit of measurement of electrical pressure ---------- 32.0
33. A temporary magnet is made of soft iron ---------- 30.7
34. The three parts of the three element radio tube are the grid, plate, and filament ---------- 29.8*
35. The A battery of a radio circuit supplies current to the filament ---------- 26.5
36. The electron theory of matter states that an electron is negative electricity ---------- 24.6
37. An electro-magnet is a part of a telegraph sounder and a part of a doorbell ---------- 24.6
38. Two inventors in the field of wireless telegraphy and radio are Marconi and DeForest ---------- 22.4
39. If electricity costs 10 cents per kilowatt hour the cost for using twenty 25 watt lamps for one hour will be 5 cents ---------- 19.7
40. The function of a crystal in a radio set is to detect current ---------- 16.4

Table VIII-I shows the extent of mastery of various phases of the work in electricity and communication. Although 76.9 per cent of the pupils knew that the cost of electricity used in the home is figured at a certain cost for each kilowatt hour only 19.7 per cent of the same group could solve a simple problem when given the data with which to do so. Apparently, only a few of them clearly understand what a kilowatt is. The fact that only 43 per cent of the pupils could define the term ampere, and but 32 per cent could define correctly the term volt is further evidence that the units of measurements of electricity are not mastered by ninth grade pupils. Transformers and the electron theory are also not understood. Many of the scientific principles underlying communication are understood by less than half of the pupils. This is especially true of radio communication. Since only 25 per cent of the pupils know that an electron is a particle of negative electricity it is difficult to see how they

could possibly clearly understand radio communication. Apparently either the electron theory of matter is too difficult for the ninth grade or the subject is not adequately presented in textbooks or by teachers of general science.

TABLE VIII-J

Unit 10—Travel and Transportation

	Per cent Correct
1. The airplane was invented by the Wright brothers	64.8
2. Petroleum is the chief source of gasoline	63.0
3. Coal is the fuel used in most locomotives	61.5
4. The lifting force of water which causes objects to float in it is called buoyancy	58.2
5. Airships are filled with a gas lighter than air	55.2
6. When in a garage with an automobile engine running the garage should be kept open because of the dangerous carbon monoxide gas	50.3
7. The spark plug of an automobile engine is placed in the cylinder	45.0
8. A balloon is buoyed up by a force equal to the weight of air displaced	43.1
9. Proper lubrication is necessary in the care of an automobile because of friction	41.4
10. Watt invented the first useful steam engine	40.7
11. The work of the carburetor in an automobile is to control the mixture of air and gas	40.4
12. When a submarine is submerged it is run by electric storage batteries	39.4
13. When a submarine is to be submerged water is placed in tanks	38.2
14. When an automobile goes around a curve the one rear wheel moves more rapidly than the other. This is made possible by a special device called the differential	33.5
15. Archimedes' principle	30.1
16. The timer of an automobile engine is a part of the ignition system	28.0
17. A gasoline engine is more efficient than a steam engine	27.0
18. The explosion occurs in the cylinder of the four cycle gasoline engine immediately following the compression stroke	24.6
19. Two parts essential to a steam engine but not a gasoline engine are the slide valve and steam chest	24.6
20. The principal function of the fly wheel of an engine is to make the engine run smoothly	21.0

21. A hydrometer is used to test a lead storage battery ---------- 19.0
22. When the carburetor of an automobile is working properly the exhaust contains chiefly carbon dioxide and water vapor ---------- 9.2

The items in Table VIII-J test the pupil's knowledge of travel and transportation. This is the least understood unit of any tested. No question was answered by more than 64.8 per cent of the group and but six of twenty-two test items were answered by more than half of the group. If the purpose of this unit of work is to give the pupils a fund of scientific knowledge about the parts and workings of these parts of an automobile for example then much of the time and effort expended on this unit has been wasted.

OUTLINE SUMMARY

It is evident from the data presented in this chapter that so far as mastery of the core of instructional material presented in Chapter III is concerned there is much to be desired. It is apparent also that there is considerable variation in mastery of the units of subject matter of general science and also considerable variation in mastery of the various topics within the units themselves. In order further to clarify the situation the topics of each unit that were mastered by less than fifty per cent of the pupils are given below in outline summary form.

Unit 1. Atmosphere and Weather
1. Physical and chemical changes.
2. Chemistry of air.
3. Cyclones, anti-cyclones and tornadoes.
4. Relation of humidity to health and comfort.
5. Condensation products.
6. Weather maps.
7. Cloud classification and identification.
8. Prevailing winds in temperate zones.

Unit 2. Water, Water Supplies, and Sewage Disposal
1. Convection currents in water.

2. Scientific principles underlying refrigeration.
3. Density of water.
4. Irregularities in the reaction of water to changes in temperature.
5. Permanent hardness of water.
6. Heat exchanges when the temperature of water changes.
7. Relation of pressure to boiling and freezing points of water.

Unit 3. The Earth and Other Heavenly Bodies

1. Size of stars.
2. Equinoxes.
3. Cause of visibility of planets and moon.
4. Relative sizes of planets.
5. Close resemblance of Venus to the earth.

Unit 4. Rocks and Soil

1. Erosive action of freezing water.
2. Soil fertility.
3. Relationship of leguminous plants to soil fertility.

Unit 5. Foods and Nutrition

1. Vitamines (classification).
2. Food manufacture in green plants.
3. Chemical test for proteins.
4. Examples of protein foods.
5. Assimilation.
6. Chemical test for sugar.
7. Chemical elements in carbohydrates, fats, and proteins.
8. Examples of common foods rich in carbohydrates, iron, or vitamines.
9. Energy value of foods.
10. Certified milk.
11. Enzymes.

Unit 6. Life on the Earth

1. Food manufacture in plants.
2. Pollination.
3. Immunity.
4. Osmosis.

5. Protoplasm.
6. Fertilization.
7. Structure of flowers.
8. Legumes.
9. Bacteria.

Unit 7. Energy, Work, and Machines.

1. Classification of levers.
2. Wheel and axle.
3. Definition of machine, energy, kinds of energy.
4. Inertia.
5. Efficiency and mechanical advantage.

Unite 8. Heating and Lighting

1. Definition of calorie.
2. Conduction, convection, and radiation.
3. Refraction of light.
4. Candle power.
5. Light transmission.
6. Eye defects.
7. Definition of translucent.

Unit 9. Electricity and Communication

1. Chemical action in a dry cell.
2. The telephone.
3. Dynamo.
4. How to connect cells.
5. Principles underlying radio communication.
6. Transformer.
7. Electron theory.
8. How to figure cost of current.
9. Ampere and volt.

Unit 10. Travel and Transportation

1. Automobile (parts and their functions.)
2. Submarine.
3. Archimedes' principle.
4. Efficiency of engines.
5. Difference between steam engine and gasoline engine.

The following topics are understood by fifty per cent or more of the pupils.

Unit 1. Atmosphere and Weather

1. Use of the barometer.
2. Work of air pressure in lift pump.
3. Humidity.
4. Elementary principles of sound.
5. Effects of heating and cooling on gas volume.
6. Condensation and evaporation.
7. Lime water test for carbon dioxide.
8. Relation of barometric pressure to weather conditions.
9. Definition of molecule.
10. Fog, snow.
11. Relation of evaporation of perspiration to bodily temperature.
12. Convection in hot air furnace.
13. Air pressure.

Unit 2. Water, Water Supplies, and Sewage Disposal

1. Purifying water by boiling.
2. Fahrenheit and Centigrade thermometers.
3. Hardness of water.
4. Water as a solvent.
5. How cities purify their water supply.
6. Use of water traps on drain pipes.
7. Artesian wells.
8. Effects of changes of temperature on water volume.

Unit 3. The Earth and Other Heavenly Bodies

1. Solar system.
2. Planets.
3. Use of telescope and spectroscope.
4. Moon.
5. Sun as a star.
6. Constellations.
7. Eclipses.
8. Meteors.

Unit 4. Rocks and Soil

1. Definitions and examples of

(a) sedimentary rock.
(b) igneous rock.
(c) metamorphic rock.

2. Irrigation.
3. Erosion.
4. Rotation of crops.
5. Water-table line.

Unit 5. Foods and Nutrition

1. Calorie.
2. Balanced diet.
3. Digestion.
4. Pasteurization.
5. Sugar and starch as carbohydrates.
6. Value of cooking food.
7. Function of proteins and mineral matter in body.
8. Chemical test for starch.
9. Vitamines in diet.
10. Alcohol not a food.
11. Tea and coffee as stimulants.

Unit 6. Life on the Earth

1. Breeding places of flies and mosquitoes.
2. How to eliminate flies and mosquitoes.
3. Toxins and antitoxins.
4. Vaccination.
5. Food manufactured by green plants.
6. Heredity.
7. Work of white corpuseles.

Unit 7. Energy, Work, and Machines

1. Fulcrum.
2. Use of fixed and movable pulleys.
3. Friction.
4. Turbines.
5. Definition of horse power.
6. Centrifugal force.

Unit 8. Heating and Lighting

A. Heat

1. Thermometer.
2. Heating causes expansion.
3. Radiation of heat from sun.
4. Convection (definition).
5. Carbon in fuels.
6. Hot air furnace heats and ventilates.

B. Light

1. Sun.
2. Edison inventor of incandescent lamp.
3. Definition of transparent and opaque.
4. Composition of sunlight.
5. A lens forms an inverted image.
6. How to sit when reading.
7. Sunlight best light to match colored goods by

Unit 9. Electricity and Communication

1. Telephone invented by Bell.
2. Polarity of magnets.
3. Lighting.
4. Kilowatt hour.
5. Fuse.
6. Motor in vacuum cleaner.
7. Compass.
8. Telegraph invented by Morse.
9. Copper is a good conductor.
10. Function of a transformer.
11. Heating effects of electricity (applications).
12. Electro magnet.
13. Static electricity.

Unit 10. Travel and Transportation

1. Airplane invented by Wright Brothers.
2. Petroleum chief scourse of gasoline.
3. Buoyancy of water.
4. Airships filled with gases lighter than air.
5. Dangers of carbon monoxide gas.

CHAPTER V

THE RELATION OF INTELLIGENCE TO ACHIEVEMENT IN GENERAL SCIENCE

Up to this point we have been concerned mainly with two things: (1) the content of general science courses, and (2) the extent to which the basic instructional material of general science courses is being mastered by ninth grade pupils. In this chapter our chief concern is the relation of intelligence to achievement in general science.

Pupil achievement in a school subject is conditioned by a considerable number of variable factors. The mark a pupil makes on an achievement test is one measure of the result of the interaction of these causal factors. The fact that these conditioning factors are not present or do not exercise their effect in the same degree upon each pupil explains the individual differences and variability in achievement that teachers commonly find in their classes.

Intelligence is one of the most important of these factors that affect achievement. While the coefficient of correlation between intelligence test scores and achievement test scores is never +1, it has been demonstrated by experiment that the correlation approaches unity as pupils are "maximally or equally motivated." "Indeed," says Symonds[1], "no other single factor has been found that conditions achievement in this inclusive way."

This part of our investigation deals with a study of the relation of mental ability to achievement in general science. Two things are attempted: (1) to show the relation of intelligence to achievement in high school general science and (2) to set standards for achievement in general science in terms of the scores on an intelligence test.

[1]Symonds P. M. *Ability Standards for Standardized Achievement Tests in the High School*, Bureau of Publications, Teachers College, Columbia University, New York City. p. 2.

COLLECTION OF DATA

In the fall of 1928 letters were sent to a number of general science teachers in the United States explaining the purpose of this investigation and asking them to cooperate in the study. Of the schools replying favorably, ten[2], fairly well distributed geographically, were chosen to carry on a testing program during the year. Due to the failure of several teachers to report data for December 1st and March 1st, it was necessary to continue the testing during the school year of 1929-30.

In each of these schools the Terman Group Test of Mental Ability was administered to the pupils early in the fall, most frequently during the month of October. Either Form A or Form B was used. In one of the cooperating schools, the Terman Test had been given in the fall of 1927 but not 1928. The Terman Test scores of the pupils studying general science in this school were corrected to 1928 by means of the regression equation.

$$Y_{\text{gain}} = -169\, X_{\text{score}} - 40.62$$

and a table for estimating yearly gain on the Terman Test for high school pupils, both of which have been derived by Symonds[3].

Pupil achievement in general science in these schools was determined three times during the year (December 1st, March 1st, and June

[2]The author is indebted to the following teachers and schools who assisted in the testing program:
Baer, Ruth E., High School, Emmittsburg, Md.
Carrol, B. S., High School, Trappe, Md.
Cochran, Samuel G., Commerce H. S., Yonkers, N. Y.
Cuzner, Hazel, Albert Lea H. S., Albert Lea, Minn.
Davee, H. A., High School, Geraldine, Montana.
Flatt, John B., High School, Twin Falls, Idaho.
Hosfeld-Hamparian, Francis, High School, Fort Lee, N. J.
Kennedy, R., Junior High School, Maplewood, N. J.
Le Mahieu, James, High School, Grafton, Wis.
Smith, Charles, Radnor H. S., Wayne, Penna.

The following teachers cooperated in the 1929-30 testing program:
Fletcher, Cora T.,High School, Concord, N. H.
Schultz, W. R., High School, Faribault, Minn.
Carroll, Benjamin S., High School, Trappe, Md.
Albertson, Mary S., High School, West Palm Beach, Fla.

[3]Symonds, op.cit., p. 47.

1st) by means of the Powers General Science Tests[4]. In November the following set of directions was sent to the cooperating schools.

DIRECTIONS TO COOPERATING SCHOOLS

Under separate cover, I am sending copies of the Powers General Science test Form A. The dates set for the testing during the year, you will recall, are December 1, March 1, and June 1. This group of tests need not be given exactly on December 1, within a week before or a week after will be satisfactory.

To insure uniformity in the testing program, the following set of directions has been prepared. Please read them very carefully.

1. The Powers General Science test normally requires a full period to be administered. Since much of the material in the test will not have been covered by December 1, a full period will not be required at this time. Collect the tests as soon as the pupils complete them.

2. The teachers should not discuss the tests with the pupils after they are taken. This test Form A will probably be given again during the year and to discuss the test or answer pupils questions may invalidate future testing.

3. Teachers should not modify their teaching procedures because of the testing program. Continue your work as you normally do it. A number of schools throughout the United States are cooperating in this investigation which should furnish a measure of achievement in General Science under normal teaching conditions.

4. Do not make any attempt to prepare classes directly for this test. To do so would defeat the purpose of the investigation.

5. Do not give the test to pupils repeating the course in General Science.

[4]Published by Bureau of Publications, Teachers College, Columbia University, New York City.

6. On the front page of each test, in the *upper right hand* corner write the pupils Terman Test score (please note score not I Q).

7. Please send me the December 1, tests as soon as possible after they have been given. I hope I may have all of them by December 15.

Similar procedures were followed for the March 1st and June 1st testings with the exception that the Powers General Science Test Form B was used for the March 1st testing. Form A was again used for the June 1st testing.

TREATMENT OF THE DATA

The scores made on each test at each period of testing were distributed in a scatter-diagram by plotting the Terman Test scores along one axis and the Powers Test scores along the other. Table IX gives the distribution of these scores for each period of testing.

Medians, quartiles, and semi-interquartile ranges were calculated for both tests at each period of testing. All of these data are summarized in Table X.

TABLE IX

Distribution of Scores on Both Tests for Each Period of Testing

December 1st				March 1st				June 1st			
Terman		Powers (A)		Terman		Powers (B)		Terman		Powers (A)	
Score	f	Score	f	Score	f	Score	f	Score	f	Score	f
170	4	54	5	179	2	62	2	184	1	83	1
163	1	52	1	172	3	60	3	177	6	80	0
156	1	50	5	165	1	58	8	170	3	77	2
149	8	48	11	158	2	56	4	163	6	74	2
142	19	46	12	151	7	54	4	156	6	71	10
135	13	44	10	144	9	52	8	149	21	68	10
128	23	42	9	137	11	50	16	142	21	65	10
121	29	40	32	130	30	48	15	135	16	62	20
114	48	38	17	123	18	46	24	128	29	59	26
107	33	36	39	116	39	44	13	121	42	56	25
100	49	34	25	109	39	42	26	114	23	53	42
93	39	32	43	102	48	40	38	107	41	50	32
86	41	30	38	95	29	38	28	100	39	47	37
79	27	28	36	88	51	36	34	93	43	44	48
72	34	26	22	81	32	34	45	86	42	41	47
65	17	24	32	74	35	32	30	79	21	38	28
58	15	22	28	67	26	30	45	72	22	35	17
51	4	20	19	60	9	28	15	65	15	33	31
44	3	18	3	53	8	26	22	58	9	29	13
37	1	16	16	46	2	24	10	51	11	26	14
30	1	14	0	39	4	22	7	44	6	23	2
		12	0	32	3	20	7	37	3	20	2
		10	7			18	4	30	1	17	2

TABLE X

Summary of Test Results for December 1st, March 1st, and June 1st

Date	N	Terman Test				Powers Test			
		Med.	Q_1	Q_3	Q	Med.	Q_1	Q_3	Q
December 1st	410	104.0	86.1	120.3	34.2	32.2	25.8	38.0	12.2
March 1st	408	102.7	84.3	119.5	35.2	37.1	31.6	43.6	12.6
June 1st	421	106.7	88.9	127.6	38.7	47.5	40.6	56.1	15.5

TABLE XI

Correlation between Terman Group Test of Mental Ability and the Powers General Science Test

December 1st	.35
March 1st	.42
June 1st	.67
Average	.48

TABLE XII

Ability Standards for Powers General Science Test

Terman Score	Dec. 1	March 1	June 1
165	55.5	59.5	68.7
160	53.5	57.5	66.7
155	51.7	55.5	64.7
150	49.8	53.8	62.7
145	48.0	52.0	60.7
140	46.0	50.5	58.7
135	44.5	49.0	56.7
130	42.5	47.0	54.7
125	40.5	45.5	52.6
120	39.0	44.0	50.7
115	37.5	42.0	48.6
110	35.0	40.6	46.7
105	33.0	39.0	44.6
100	31.7	37.5	42.7
95	30.0	35.8	40.7
90	28.4	34.0	38.7
85	26.5	32.5	36.7
80	24.5	30.8	34.7
75	22.7	29.0	32.6
70	20.7	27.0	30.6

TABLE XIII

Computation of Ability Standards for June 1st

%	%×N	TERMAN SCORE	TERMAN F	TERMAN PERCENTILE VALUES	POWERS SCORE	POWERS F	POWERS PERCENTILE VALUES
100	421.00	184–190	1	$156+\frac{95}{6}\times 7=157.0$	83–85	1	$68+\frac{3.95}{10}\times 3=69.2$
95	399.95	177–183	6				
90	378.90	170–176	3	$149+\frac{.9}{21}\times 7=149.0$	80–82	0	$62+\frac{12.90}{20}\times 3=63.9$
85	357.85	163–169	6		77–79	2	
80	336.80	156–162	6	$135+\frac{10.85}{16}\times 7=139.7$	74–76	2	$59+\frac{17.85}{26}\times 3=61.1$
75	315.75	149–155	21				
70	294.70	142–148	15	$128+\frac{18.8}{29}\times 7=132.5$	71–73	19	$56+\frac{21.80}{25}\times 3=58.6$
65	273.65	135–141	16				
60	252.60	128–134	29	$121+\frac{39.75}{42}\times 7=127.6$	68–70	10	$56+\frac{.75}{25}\times 3=56.1$
55	231.55	121–127	42		65–67	10	
50	210.50	114–120	23	$121+\frac{18.7}{42}\times 7=124.1$	62–64	20	$53+\frac{21.7}{42}\times 3=54.6$
45	189.45	107–113	41		59–61	26	
40	168.40	100–106	39	$114+\frac{20.65}{23}\times 7=120.3$	56–58	25	$53+\frac{.65}{42}\times 3=53.0$
35	147.35	93– 99	43				
30	126.30	86– 92	42	$107+\frac{40.6}{41}\times 7=114.0$	53–55	42	$50+\frac{11.60}{32}\times 3=51.1$
					50–52	32	
25	105.25	79– 85	21	$107+\frac{19.55}{41}\times 7=110.4$	47–49	37	$47+\frac{27.55}{37}\times 3=49.2$
20	84.20	72– 78	22				
15	63.15	65– 71	15	$100+\frac{37.5}{39}\times 7=106.7$	44–46	48	$47+\frac{6.50}{37}\times 3=47.5$
10	42.10	58– 64	9				
5	21.05	51– 57	11	$100+\frac{16.45}{39}\times 7=103.0$	41–43	47	$44+\frac{33.45}{48}\times 3=46.1$
		44– 50	6		38–40	28	
.....	.....	37– 43	3	$93+\frac{38.4}{43}\times 7=99.3$	35–37	17	$44+\frac{12.40}{48}\times 3=44.8$
.....	.....	30– 36	1	$93+\frac{17.35}{43}\times 7=95.8$	32–34	31	$41+\frac{38.35}{47}\times 3=43.4$
					29–31	13	
.....	.....	.....		$86+\frac{38.30}{42}\times 7=92.4$	26–28	14	$41+\frac{17.30}{47}\times 3=42.1$
					23–25	2	
.....	.....	.....		$86+\frac{17.25}{42}\times 7=88.9$	20–22	2	$38+\frac{24.25}{28}\times 3=40.6$
.....	.....	.....		$79+\frac{17.20}{21}\times 7=84.7$	17–19	2	$38+\frac{3.20}{28}\times 3=38.3$
.....	.....	.....		$72+\frac{18.15}{22}\times 7=77.8$	.....		$32+\frac{30.15}{31}\times 3=34.9$
.....	.....	.....		$65+\frac{12.10}{15}\times 7=70.6$	.....		$32+\frac{9.10}{31}\times 3=32.9$
.....	.....	.....		$58+\frac{.05}{9}\times 7=58.0$	.....		$29+\frac{1.05}{13}\times 3=29.2$

The coefficients of correlation between the Terman Group Test of Mental Ability and the Powers General Science Test were calculated for each period of testing by the product-moment method. These coefficients are shown in Table XI.

The statistical method[5] of deriving the standards for June 1st will now be described in detail. The reader should refer to Table XIII. In column one the per cents by steps of five to 100 are given. The figures in column two were obtained by multiplying 421 (N) by the percentages in column one. The next section of the table shows the data and computation of every fifth percentile value for the distribution of scores for the Terman Test. The last section shows the data and computation of every fifth percentile for the distribution of scores on the Powers General Science Test.

The corresponding percentiles are next plotted on a sheet of cross section paper. The points are joined so as to form a straight line. If the points are not already in a straight line a line of best fit is made by use of "judgment, eye, and pencil." From this line values are ready for the Powers General Science Test, for every five points of score on the Terman Test. These values are the ability standards. Table XII gives the standards for December 1st, March 1st, and June 1st.

[5]An excellent discussion of the theory and practice underlying this statistical procedure can be found in Section 2 of Symonds' monograph, already cited in this chapter.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The data presented in this monograph are the results of an attempt to determine the content and degree of mastery of modern ninth grade general science courses.

In the first part of the investigation an attempt has been made to determine what facts, principles, and applications of science constitute the nucleus of our present day general science courses. In Chapter three of this monograph there is presented a detailed analysis of the core content of general science courses as determined by an analysis of seven modern general science text books. The analysis reveals what may be termed the basic instructional materials of general science. The materials are grouped under the following unit headings:

1. Atmosphere and Weather
2. Water, Water Supplies, and Sewage Disposal
3. The Earth and Other Heavenly Bodies
4. Rocks and Soil
5. Foods and Nutrition
6. Life on the Earth
7. Energy, Work, and Machines.
8. Heating and Lighting
9. Electricity and Communication
10. Travel and Transportation
11. Clothing
12. Home and Building Construction

The second phase of the study presents the results of a testing program carried on to determine to what extent the basic instructional materials of general science are being mastered by ninth grade pupils. Objective tests were constructed for each of the units of subject matter determined by the text book analysis presented in Chapter three.

These were then administered to an unselected group of pupils who had just completed a year's study of General Science in the ninth grade. In Chapter four tables are presented showing to what extent the basic facts, principles, and applications of science which constitute the ninth grade general science course are mastered by these pupils.

The last phase of the investigation is confined to a study of the relation of intelligence to achievement in general science. The Powers General Science Test was administered at three different periods (December 1st, March 1st, and June 1st) during the year to pupils studying ninth grade general science. These pupils were also given the Terman Group Intelligence test in the fall of the year. From the data collected the correlation between intelligence and achievement in general science was calculated. Ability standards for achievement in general science were also calculated from the Powers General Science Test Scores and the Terman Intelligence Test Scores. These data are all presented in Chapter five. They should prove valuable to teachers in estimating the efficiency of their pupils and their classes.

CONCLUSIONS

1. A common core of instructional materials has crystallized which forms the nucleus of present day ninth grade general science courses.
2. Most of the facts and principles of science developed in general science courses are not being mastered by a large percentage of students exposed to them. This indicates to curriculum specialists the necessity of providing situations in general science courses through which scientific concepts will be built up.
3. There is considerable variation in the extent of mastery of the units of subject matter of general science and also great variation in extent of mastery of the various topics within the units themselves. By examining the tables presented in Chapter four, teachers can ascertain the general science topics that are not being mastered by ninth grade pupils under present conditions of teaching which may aid them in adjusting their teaching to the various levels of intelligence represented in their classes so that mastery will result.

4. Intelligence is a factor which conditions the achievement of pupils in general science. The ability standards presented in Chapter five should enable teachers to determine whether or not the pupils in their general science classes are working up to their ability levels.

IMPLICATIONS

General science has won a place in the curriculum of secondary schools because leaders in the field of secondary education believe it is better able to contribute to the realization of the objectives of modern education than the specialized science courses which it has replaced. Not only is there a widespread belief in the efficacy of general science but there is almost a unanimity of opinion as to what this course should accomplish. The general aims of general science have already been stated in the introductory chapter of this monograph. Professor Thomas H. Briggs writing in Teachers College Record, April 1931 stated: "We have developed general science to the point that the great majority of students have fundamental knowledge in this important field and some acquaintance with what higher specialization offers." Professor Briggs also believes that this is one of the "four most significant developments in our secondary schools."

There is however a paucity of scientific evidence to show that the aims of general science are being realized. Are pupils after they have completed the course in general science able to use the scientific method in solving problems? Do they have scientific attitudes? Are they able more intelligently to elect the special sciences of biology, chemistry, and physics? Do they gain enough knowledge of facts, principles, and applications of science so that they have a better understanding and control of their environment?

The data presented in this study show clearly that most of the facts, principles, and applications of science which are to lead the pupils to a better understanding and control of their environment are not mastered by ninth grade pupils. One is naturally led to inquire why this condition exists. It is quite likely that teachers of general science are attempting to cover too much subject matter

which results in superficiality of learning by the pupils. While this study does not prove it, the data do furnish a basis for speculating also that certain topics within the general science course may be too difficult for the ninth grade.

It is likely also that general science is "suffering" because it is general. We are attempting to bring pupils to an understanding of their environment rather than an understanding of any special sciences which leads to ramifications into many fields of science. As a result general science text books have become encyclopedic in nature and may be beyond the possibility of mastery by average ninth grade pupils.

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APPENDIX A

The Distribution of the Tests Among the Eight High Schools That Cooperated in the Testing Program Described in Chapter 4.

Unit	South Division Milwaukee	Washington Milwaukee	North Division Milwaukee	West Division Milwaukee	Sheboygan	West Allis	Grafton	Shorewood	Total
1. Atmosphere and Weather	44	66	28	70	53	77	19	50	407
2. Water	48	75		66	48	78	18		333
3. Earth and Other Heavenly Bodies	48	75		66	48	78	18		333
4. Rocks and soil	68	73	21	55	46	84	19		366
5. Foods and Nutrition	68	73	21	55	46	74	19		356
6. Life on the Earth	66	73	21	57	51	78	19		365
7. Energy, Work, and Machines	44	71		56	51	80	19	70	391
8. Heating and Lighting	44	71		64	51	80	19	70	399
9. Magnetism, Electricity, and Communication	66	73	21	57	51	78	19	60	425
10. Travel and Transportation	44	71		60	51	80	19	70	395
Total									3770

APPENDIX B

UNIT TESTS FOR GENERAL SCIENCE

1. Name _____
2. Boy or Girl _____ Grade _____
3. Age last birthday _____ Date of Birthday _____
4. Name of City _____
5. Name of School _____
6. Name of Teacher _____
7. Date _____
8. Intelligence record (I. Q.) _____

If you have studied any of the following subjects indicate in the blanks how many weeks.

General Science _____ weeks Physics _____ weeks
General Biology _____ weeks Chemistry _____ weeks

List other courses in science which you are taking or have taken.

_____ _____ weeks
_____ _____ weeks

DIRECTIONS

This is a test of your knowledge of science.

Test items similar to the following illustration are on the following pages.

Illustration:

(a) The steamboat was invented by
Edison Ford Fulton Franklin Marconi

In the illustration the name of Fulton is underscored because it makes the statement true. In like manner you are to underline the word or group of words which most satisfactorily complete the statements on the following pages.

(b) In a few of the statements a part of the sentence is left blank. You are to fill each blank with a word so as to make the statement complete and true.

UNIT—ATMOSPHERE AND WEATHER

1. When an empty drinking glass is inverted and pushed under water it remains practically
   full of air water completely fills the glass
   the air is forced out
   most of the air dissolves in the water
   water rises halfway
2. Heating causes gases to
   liquify evaporate contract expand oxidize
3. Heat from a hot air furnace is distributed throughout a house mainly by
   radiation conduction convection diffusion reflection
4. The average air pressure at sea level is sufficient to support a column of mercury of
   24 inches 27 inches 30 inches 76 inches 30 feet
5. A pump used to force air into a container is called a
   compression pump force pump suction pump
   Pelton pump high tension pump
6. Water rises from a well into a lift pump due to
   air pressure gravity buoyancy inertia diffusion
7. A bicycle pump is an
   exhaust pump suction pump lift pump
   compression pump force pump
8. The instrument used to measure air pressure is called a
   thermometer barometer hygrometer manometer
   anemometer
9. The instrument used by aviators to determine their altitude is called a
   manometer aneroid barometer thermometer
   galvanometer cyclometer
10. The boiling point of water by the Fahrenheit thermometer is
    100° 32° 212° 200° 0°
11. The freezing point of water by the Fahrenheit thermometer is
    100° 0° 212° 32° 22°

12. Mercury is used in a thermometer because when warmed it
    expands quickly gets heavier sublimes is easy to see changes to liquid
13. The boiling point of water on the centigrade scale is
    32° 212° 200° 100° 273°
14. The freezing point of water on the centigrade scale is
    32° 10° 0° −10° −15°
15. Average air pressure per square inch at sea level is about
    5 lbs. 1 lb. 25 lbs. 15 lbs. 12 lbs.
16. A balloon is buoyed up by a force equal to the
    weight of air displaced weight of the gas in the bag
    weight of the ballast barometic pressure
    air currents
17. A pump which removes air from a container is called a
    water pump compression pump lift pump
    exhause pump force pump
18. A division on the centigrade scale is equial to _____ divisions on the Fahrenheit.
19. Air is a
    compound substance mixture of elements
    mixture of two compounds single element
    mixture of compounds and elements
20. Molecules are made up of two or more particles called
    electrons gases atoms meteors protons
21. The three states of matter are _____, _____, _____.
22. When a burning splint of wood is put into a bottle and stoppered it soon goes out because of insufficient
    oxygen hydrogen nitrogen carbon dioxide
    water vapor
23. The ratio of nitrogen to oxygen in the air is approximately
    1 to 1 4 to 1 4 to 5 1 to 2 3 to 5
24. Water may be separated into hydrogen and oxygen by
    boiling hydrolysis electrolysis inertia
    photosynthesis

25. A yellow gas flame is due to the presence in the flame of
gases water vapor carbon particles carbon dioxide
carbon monoxide
26. A substance whose molecules are made up of two or more kinds of atoms is called
an electron a complex substance a chemical compound
an element an impure substance
27. An example of a chemical compound is
lead oxygen water nitrogen iron
28. A physical change is illustrated when
iron rusts coal burns food decays milk sours
wood is changed to sawdust
29. A chemical change is illustrated when
water freezes dew condenses air is liquefied
coal burns gases are diffused
30. Carbon dioxide may be made in the laboratory by
heating potassium chlorate burning sulfur
treating marble with hydrochloric acid
electrolysis photosynthesis
31. The first mercury barometer was made by
Galileo Torricelli Edison Newton Ford
32. Carbon dioxide is
lighter than air heavier than air same weight as air
same weight as water lighter than water vapor
33. When carbon dioxide is passed through lime water the liquid
remains clear becomes cold becomes milky
turns red becomes hot
34. Nitrogen in the air is a direct benefit to man because it
aids burning dilutes the oxygen purifies the air
combines with carbon dioxide is food for animals
35. Zinc, mercury, hydrogen, and carbon are all
gases compounds metals elements minerals
36. Hydrogen is often used in balloons because
it is cheap it does not burn it is colorless
it is buoyant it is the lightest known gas

37. Oxygen is made in the laboratory by heating
lime water potassium chlorate sodium carbonate acid
38. Change of a liquid to the gaseous state is called
condensation precipitation evaporation capillarity contraction
39. Changing of a gas to the liquid state is called
evaporation condensation buoyancy compression convection
40. The cooling effect noticed when a person perspiring freely is exposed to a draft is due to
evaporation poor circulation overheating condensation exhaustion
41. When a definite quantity of air contains all the moisture it can hold it is
vaporized compressed oxidized diffused saturated
42. The term humidity refers to
oxygen in the air expansion of air moisture in the air buoyancy of air carbon dioxide in air
43. The difference between the reading of a dry bulb thermometer and the wet bulb thermometer at the same room temperature, gives an indication of
relative humidity average room temperature density of air purity of air temperature for comfort
44. When a crowded room feels close, the discomfort is due mainly to
crowd poisoning presence of carbon dioxide lack of oxygen excessive humidity dust particles
45. Bodily temperature is in large part regulated by
proper diet exercise evaporation of perspiration bathing fresh air
46. A rising barometric pressure indicates the approach of
clear weather approaching storm heavy winds light winds cloudy weather
47. A falling barometric pressure indicates the approach of
clear weather heavy winds a tornado light winds approaching storm

48. Lines drawn on a weather map representing places of equal temperature are called
    circles isobars parallels meridians isotherms
49. The prevailing winds of the United States move across the continent from
    east to west west to east north to south south to north
    southeast to northwest
50. A spiral destructive storm of a small area is called a
    thunderstorm cyclone tornado anticyclone
    monsoon
51. A spiral movement of air often a thousand miles in diameter moving across the United States in an easterly direction is called a
    monsoon tornado hurricane cyclone windstorm
52. One of the main causes of unequal rainfall in different parts of the United States is
    large cities rivers mountain ranges forests
    dust in air
53. Raindrops which are carried to high altitudes by upward currents of air frequently fall to the earth as
    snow hail sleet rain frost
54. Moisture which condenses in the air at a temperature below 32°F falls as
    snow rain sleet hail dew
55. Water vapor condensed around dust particles near the surface of of the earth forms
    clouds rain fog dew sleet
56. Condensation of water around dust particles in the air forms
    sleet dew clouds rain hail
57. A anticyclone is usually accompanied by
    cool and wet weather low pressure
    cool and clear weather wet and warm weather
    hot and dry weather
58. In the United States a southeast wind is usually accompanied by
    low humidity cloudy weather and rain frost
    cool and clear weather thunder storms

59. The kind of clouds which appears before thunderstorms is called
numbus cirrus stratus cumulus cumulus-stratus

60. The fleecy clouds very high in the air are called
numbus cirrus cumulus stratus fracto-cumulus

61. The clouds which cover the whole sky on dark cloudy days are called
stratus cirrus numbus cumlus-stratus cumulus

62. The prevailing winds in the temperate zones of the earth are called
trade winds monsoons westerlies calms northers

63. Carbon dioxide is
poisonous non-poisonous explosive ductile combustible

64. For comfort and health the temperature of a room by the Fahrenheit thermometer should be about
10° 68° 20° 60° 78°

65. A desirable relative humidity indoors is
15° 20° 30° 50° 75° 100°

66. Unpleasant odors in a room filled with people are due mainly to
materials from lungs water vapor in breath
carbon dioxide excretions from the skin
lack of oxygen

SOUND

67. Sound is produced by
friction vibrating matter chemical action
electricity induction

68. The speed of sound in air per second is about
186,000 mi. 5000 feet 2500 feet 1100 feet
550 feet

69. Sound travels most rapidly in
water air solids vacuum partial vacuum

70. The speed of sound compared with light is
less greater equal slightly greater ½ as great

71. The sensation of hearing is felt through
optic nerve olfactory nerve auditory nerve
gustatory nerve
72. The pitch of sound depends upon
numbers of vibrations per second density of air
kind of body producing the vibrations
the eardrum intensity
73. A musical instrument whose source of sound is a vibrating reed is the
cornet clarinet flute violin piano
74. The phonograph was invented by
Edison Morse Bell Ford Whitney
75. The phonograph is a device that
reflects sound refracts sound reproduces sound
intensifies
76. In a piano the source of sound is vibrating
reeds air columns strings pipes bells
77. Sound is carried by
air waves ether waves convection currents
radiation conduction vibrations

UNDERSCORE TWO

78. Two substances formed when a candle burns are
water oxygen hydrogen nitrogen carbon dioxide
79. Two common applications of compressed air are
automobile tire lift pump soda straw air brake
fountain pen siphon
80. Two elements liberated by the electrolysis of water are
hydrogen sodium helium nitrogen oxygen argon
81. Two examples of oxidation are
wood burning condensation of water iron rusting
evaporation of water photosynthesis
82. Two gases present in air in largest quantities are
hydrogen oxygen carbon dioxide water vapor
argon nitrogen
83. Two chemicals used in a common form of fire extinguisher are
acid base potash nitrates soda lime

84. The two chemicals which are mixed and heated in the preparation of oxygen are
hydrochloric acid manganese dioxide sulfuric acid
potassium chlorate mercuric oxide magnesium

UNIT—WATER

1. The boiling point of water by centigrade thermometer scale is
10° 32° 12° 200° 100°
2. The boiling point of water by Fahrenheit thermometer scale is
100° 0° 212° 32° 22°
3. The freezing point of water by the Fahrenheit thermometer scale is
32° 212° 22° 0° 4°
4. The freezing point of water by the Centigrade thermometer scale is
10° 32° 212° 0° 100°
5. Water may exist as either of the following forms
---------- ---------- or ----------
6. The freezing temperature and the melting temperature of water
are the same are unequal differ by one degree
have no relationship differ by 4° C
7. Water contracts on cooling until it reaches
0°C. —4°C. 4°C. 32°F. 100°C.
8. Water has its greatest density at
32°F. 21°F. 0°C. 4°C. 100°C.
9. When water freezes its volume
decreases condenses increases evaporates
takes in heat
10. As a quantity of water changes from liquid to ice its temperature
drops 4 degrees rises to 4°C. gradually decreases
remains constant increases
11. Reducing pressure on water ----------, the boiling point, while increasing pressure on water ---------- the boiling point.

12. Steam is used in a steam engine because expanding steam is
hot is cooling is diffused exerts pressure
creates suction
13. Ice floats because it is
heavier than water a solid lighter than water
condensed diffused
14. A cubic foot of water weighs about
35.5 lbs. 1 lb. 32.5 lbs. 100 lbs. 62.4 lbs.
15. As water changes into steam it
decreases in volume has same volume condenses
increases in volume diffuses
16. The weight of a cubic centimeter of water in grams is
0.5 1 1.5 2 4
17. Water is an
element mixture solution hybrid
chemical compound
18. Water can be decomposed into its elements by
evaporation freezing boiling hydrolysis
electrolysis
19. Water is considered
the universal solvent a poor solvent not a solvent
20. Hardness of water is due to presence of dissolved compounds of
iron aluminum calcium and magnesium salts
sodium and potassium salts oxygen and hydrogen compounds
21. Soft water is water which does not contain dissolved
oxygen carbon dioxide minerals nitrogen
rare gases
22. Permanently hard water may be softened by
boiling freezing filtering use of chemicals
convection
23. Temporary hard water can be softened by
filtering boiling freezing diffusion stirring
24. Living organisms in water may be killed by
freezing filtering stirring boiling a sudden jar

25. The disease most commonly spread by drinking water is
diptheria small pox mumps typhoid fever
tuberculosis

26. The separation of liquids and dissolved solids by evaporation and condensation is called
diffusion transpiration solution distillation
pasteurization

27. During the process of evaporation
heat is taken in heat is given out no heat exchange

28. A practical use of the loss of heat by evaporation is in
refrigeration distillation pasteurization
boiling inoculation

29. Does melting ice take in or give off heat?
(Write answer here) _____

30. In the ammonia ice machine when the liquid ammonia evaporates are the coils cooled or heated? (Answer) _____

31. In the ammonia ice machine when the gaseous ammonia is condensed to liquid ammonia are the coils cooled or warmed?
(Answer) _____

32. Where there is no pump the pressure of the water in the pipes in our houses is due primarily to the
weight of the water size of the pipes
purity of the water height of the source

33. What are the three common classes of impurities of water?
(Answer) _____ _____ _____

34. The most dangerous impurity in water is usually
minerals bacteria decaying organic matter chemicals

35. Water can be purified in the home for drinking purposes by
stirring freezing compression boiling
adding lysol

36. The most dependable source of pure water is
cisterns shallow wells deep driven wells
large rivers lakes

37. Wells from which water flows without pumping are called
artesian diffused cisterns reservoirs capillaries

38. The most satisfactory disposition of sewage is by emptying it into
rivers cesspools lakes septic tanks
using it for garden fertilizer
39. To prevent sewer gases entering the house, drain pipes are connected by
water traps iron bolts condensers leather washers
faucets
40. Currents set up in water by heating are called
conduction radiating convection diffusion
suspension
41. In a hot water heating system the heat is carried from the boiler to the radiators by
convection conduction radiation diffusion
capillarity
42. What are the three most common types of faucets?
(Answer) ---------- ---------- ----------

UNDERSCORE TWO

43. Water is composed of the two elements
hydrogen nitrogen oxygen carbon helium
sodium
44. Permanent hardness of water may be due to dissolved
calcium sulphate oxygen carbon dioxide iron
magnesium sulfate nitrogen
45. The two treatments used by cities to purify the water supply are
freezing filteration boiling adding chemicals
electrolysis stirring
46. Two safe methods of destroying sewage are
contact filter beds cesspools running into rivers
emptying into lakes septic tanks spreading over land

UNIT—EARTH AND OTHER HEAVENLY BODIES

1. The sun is a
planet star comet meteor satellite
2. The sun, planets and their moons together form the
solar system universe nebulae world constellation

3. The number of planets is
   10 3 8 9 7
4. The largest planet is
   Jupiter Mars Uranus Venus Mercury
5. The nearest planet to the sun is
   Mercury Venus Neptune Jupiter Uranus
6. The smallest planet is
   Uranus Saturn Neptune Mercury Mars
7. The earth is a
   constellation satellite star planet moon
8. The force which holds the heavenly planets in their courses is called
   rotation gravitation revolution magnetism repulsion
9. The planet with a system of rings around it is
   Saturn Mars Mercury Venus Neptune
10. Groups of stars that form conspicuous figures in the sky are called
    planets satellites nebulae constellations meteors
11. The Big Dipper is a
    star planet moon constellation nebulae
12. The North Star can be located by two stars in
    Little Dipper Orion Milky Way Big Dipper
    Spiral Nebulae
13. Day and night are caused by
    rotation of earth on its axis revolution of earth
    rotation of the sun phases of the moon
14. One cause of the change of seasons is the earth's
    size speed inclination on axis density
    distance from the sun
15. The stars are classified according to brightness into
    constellations magnitudes nebulae satellites
    planets
16. The center of our solar system is the
    earth moon sun Mars North Star
17. The distance from the earth to the sun in miles is approximately
    7,000,000 92, 000 93,000,000 240,000
    75,000

18. An instrument through which the stars are studied is a
    microscope field glass telescope reflector periscope
19. The source of energy on the earth is the
    moon nebulae planets Jupiter sun eclipse
20. The passing of the moon directly between the sun and earth causes
    eclipse of moon day and night seasons storms eclipse of sun
21. The instrument used to determine the elements in the sun is called a
    spectroscope telescope microscope periscope photometer
22. The phases of the moon are caused by its movement
    on its axis about the sun about the earth
23. The periods of the year when days and nights are equal are called
    solstices meridians parallels equinoxes seasons
24. The North Pole of the earth points toward the
    sun Cassiopeia Big Dipper North Star universe
25. The surface of the moon is covered with
    water trees canals craters atmosphere
26. "Shooting stars" are properly called
    comets planetoids planets meteors stars
27. Light travels in miles per second
    250 85,000 186,000 224,000 650
28. The planet whose physical conditions are most like our earth is
    Venus Mars Mercury Jupiter Saturn
29. Is the idea, that the heavenly bodies exert evil influences on the lives of people, true?
    Yes No Partly True
30. The statement that some of the stars are larger than the sun is
    true false uncertain true of but two stars
31. Two bodies that are visible by reflected light are (underscore two)
    sun moon stars planets meteors comets

32. The diameter of the moon is
    less than of the earth
    about the same as of the earth
    about the same as of the sun
    about the same as of Mars
33. Phases of the moon are known to affect
    rainfall temperature tides plant growth radio
34. The telescope was invented by
    Darwin Whitney Marconi Herschel Galileo

UNIT—SOILS AND ROCK

1. Rocks formed of sediment deposited by water are called
   metamorphic sedimentary igneous granite marble
2. Rocks formed by heat and pressure are called
   igneous sedimentary metamorphic conglomerate shale
3. Rocks formed from hot molten matter are called
   sedimentary igneous conglomerate metamorphic limestone
4. An example of a sedimentary rock is
   limestone granite marble quartz slate
5. An example of a metamorphic rock is
   granite marble limestone quartz mica
6. An example of an igneous rock is
   granite shale coal marble limestone
7. Soils are classified according to their
   density color size of particle capillarity location
8. Humus is composed chiefly of
   bacteria fertilizer lime organic matter potassium
9. The wearing away of the soil and rocks is called
   irrigation cultivation sedimentation erosion conservation
10. Glaciers consist largely of
    sediment rock ice vegetation streams

11. Soil is protected from erosion by
    vegetation irrigation reclamation fertilization
12. Deltas are formed by
    lakes oceans glaciers rivers geysers
13. Water is an agent of erosion when it
    evaporates condenses freezes boils contracts
14. The most common cause of erosion in desert regions is
    the wind desert plants sun extreme temperature dryness
15. Soil which can hold water best is
    black light coarse fine full of gravel
16. The soil which is most likely to be sticky after a rain is
    sandy stony loam clay humus
17. In dry farming the land is usually
    irrigated cultivated rolled free of cultivation fertilized
18. When different crops are planted in the same field on successive years we call it
    dry farming rotation of crops fertilization reclamation irrigation
19. Our best all around fertilizer is probably
    phosphates nitrates potash manure lime
20. Plants on which bacteria grow which are able to take nitrogen from the air are called
    legumes vegetables nitrodes fertility plants cereals
21. Two plants on which bacteria grow which are able to take nitrogen from the air are
    wheat clover bean corn potatoes oats
22. Fertile soil must contain
    oxygen carbon phosphorus copper hydrogen
23. Fertility of soils depends mostly upon
    its position origin form mineral content water
24. Capillary action causes water in the soil to
    rise fall remain in one position flow away evaporate

25. The level at which water stands beneath the surface of the soil is called the
    water shed spring line water table capillary table production line
26. Swampy lands have been reclaimed by use of
    irrigation dry farming fertilizers capillarity artificial drainage
27. Supplying water to the soil artificially is called
    reclamation irrigation glacial action cultivation draining
28. The United States government has undertaken some irrigation projects
    around the Great Lakes in southwest region of U . S. in New England States in Pennsylvania in Florida in northwest region of U. S.
29. The water used for irrigation is usually supplied from
    the ocean creeks dams mountain lakes wells
30. The tides of the ocean are caused by the
    moon Mars stars volcanic eruptions earthquakes
31. Soil that has been built up from deposit by rivers is called
    humus alluvium clay sand loam
32. An acid condition of the soil can be corrected by use of
    phosphates manure clover lime salt

UNIT—FOODS AND NUTRITION

1. Foods which build up or repair tissues must contain
   fats proteins carbohydrates oil mineral matter
2. Food necessary for building bones and teeth must contain
   mineral matter water fat carbohydrates proteins
3. About two-thirds of the weight of the human body consists of
   fat iron blood water oil
4. The largest percentage of our diet should consist of
   carbohydrates proteins fats oils mineral matter
5. A commonly used food rich in protein is
   tomatoes beefsteak potatoes celery spinach

6. Which of the following has the largest percentage of carbohydrate?
   meat potatoes eggs milk beans
7. Food is manufactured by
   animals green plants bacteria enzymes vitamines
8. The unit of measurement of energy value of foods is the
   cubic-centimeter gram calorie ounce liter
9. The calorie content of foods is determined by a
   hydrometer hygrometer calorimeter galvanometer detector
10. Nitrogen is found only in
    carbohydrates proteins fats oils
11. Starch in foods turns blue in presence of
    iron an acid Fehling's solution iodine ammonia
12. A common substance used to test for sugar in foods is
    iodine phosphorus Fehling's solution nitric acid lime
13. Foods that will make a grease spot on paper always contain
    fat protein carbohydrates sulfur mineral matter
14. Foods which turn yellow when treated with dilute nitric acid contain
    starch sugar proteins iron fats
15. Fehling's solution is used to test for
    starch proteins sugar calcium iron
16. Of the following the least expensive protein food is
    potatoes meat eggs beans tomatoes
17. The most nearly prefect food is
    milk bread meat corn oatmeal
18. Sugar and starch are known as
    proteins fats carbohydrates vitamines elements
19. Organic foods are those contained in
    living things salts mineral matter lifeless substances
20. Food is cooked mainly because it makes food
    taste better more digestible more sanitary
    a better appearance

21. The substances in the human body which causes chemical changes in food during digestion are
    vitamines enzymes salt blood cells stimulants
22. The digestive juice secreted in the mouth is called
    gastric juice saliva pepsin hydrochloric acid bile
23. The enzyme found in mouth secretion is
    ptyalin dentine pepsin vitamine dextrin
24. The process of changing food from solid to liquid form in the body is called
    nutrition digestion absorption oxidation metabolism
25. The percentage of butter fat in milk as it comes from the cow is about
    1 4 7 10 12 15
26. Digestion of starch begins in the
    mouth stomach small intestines large intestines gullet
27. The digestive juce secreted in the stomach is called
    gastric juice saliva bile enzyme pancreatic juice
28. Absorption of digested food takes place mostly in the
    stomach small intestines large intestines gullet mouth
29. Blood is forced through the body by the
    stomach intestines heart lungs capillary action
30. Tubes which carry pure blood away from the heart are called
    veins arteries capillaries ventricles auricles
31. Impure blood is purified in the
    stomach lungs intestines ventricles liver
32. It is necessary for good health to
    eat all carbohydrates eat a high percentage of protein
    have a balanced diet drink two quarts of water a day
33. Heating milk to a temperature of from 140° to 155° F. for a period of about 20 minutes is called
    coagulation pasteurization sedimentation sterilization certification

34. Alcohol is not considered a satisfactory food because it
warms the body is inflammable injures the nervous system is found in patent medicines.
35. Certified milk means that the milk
has been heated contains more cream is always fresher
has been bottled in a clean dairy contains more proteins
36. Coffee and tea are
foods narcotics stimulants muscle builders
aids to health
37. Polluted water in the home can be made safe for drinking by
filtering heating freezing boiling sunlight
38. Diseases such as scurvy and beri-beri are due to lack of
protein foods carbohydrates vitamines enzymes
calcium in food
39. The food with the largest energy value is
fat water sugar starch proteins
40. A disease spread by both milk and water is
cancer tuberculosis typhoid fever diptheria measles
41. Leafy vegetables should be eaten because they usually contain
starch fats enzymes vitamines proteins
42. A good substitute for meat is
rice candy nuts pie spinach
43. Of the following the most nutritious liquid is
coffee cocoa tea ginger ale wine
44. Before food is canned it should be
cooled frozen washed sterilized inspected
45. The most satisfactory method of safeguarding milk from disease germs is by
freezing certifying it adding formaldehyde
pasteurization coagulation
46. Vitamines are classified
by color by shape by letters of alphabet
by poisonous effect

UNDERSCORE TWO

47. Two foods which are rich in iron are
potatoes bread spinach egg yolk beans rice

48. Two foods which are consumed mainly because of their vitamine content are
    tomatoes oysters lean meat spinach polished rice
49. Two classes of foods which are made up of only carbon, oxygen, and hydrogen are
    proteins fats water mineral matter vitamines carbohydrates
50. Two foods rich in proteins are
    eggs cabbage bread tomatoes meat carrots
51. Heat and energy are furnished to the body mostly by
    carbohydrates proteins minerals water fats alcoholic drinks

UNIT—PLANTS AND ANIMALS

1. All the living matter within a cell is called
    protoplasm chorophyll corpuscles nucleus cell wall
2. One of the functions of the root of a plant is to
    make carbohydrates anchor plants make proteins hold up leaves to sunlight
3. The small opening through which air enters the leaves of plants are called
    nucleus guard cells embryos stomata petioles
4. The green substances present in the leaves of green plants is called
    mesophyll ovules stigma chlorophyll pollen
5. Soil water and minerals enter plants through the
    stems root hairs corolla stomata ovary
6. The passing or diffusing of liquids through a membrane is called
    photosynthesis transpiration osmosis assimilation excretion
7. Food is manufactured by plants principally in the
    leaves stems roots vacuoles root hairs
8. Green plants manufacture food only
    at night in presence of light when it rains in the early morning

9. The process by which green plants manufacture carbohydrates from water and carbon dioxide is called
   osmosis metabolism oxidation photosynthesis nutrition
10. The waste product given off by green plants while making carbohydrates is
    hydrogen minerals carbon monoxide nitrogen oxygen
11. An element commonly taken from the soil by plants is
    nitrogen oxygen hydrogen carbon carbon dioxide
12. The parts of flowers which attracts insects to them are called
    stamens sepals petals calyx pollen
13. The organs of reproduction of a plant are in the
    roots flowers leaves stems root hairs
14. The uniting of the sperm or male cell of a flower with the egg cell is called
    neutralization fertilization ignition inoculation pollination
15. The transfer of pollen from another to stigma of flowers is called
    pollination transpiration fertilization reproduction diffusion
16. The embryo of a plant is contained in the
    roots seed ovule pollen stems
17. The pollen of flowers is made by the
    pistil style stamen ovules stigma
18. Flowers which bear stamens only are called
    females pistillate staminate pollinated hybrid
19. Two other ways besides fertilization by which plants can be propogated are
    grafting diffusion photosynthesis inoculation budding cross-pollination
20. The statement that "all life comes from life," is
    false partly true true true only of plants
21. The larva of a fly is called a
    cocoon caterpillar maggot wriggler adult

22. Flies lay their eggs in
    water mud grass manure ground
23. The genus mosquito that carries malaria germs is called
    anopheles culex stegomyia vertebrate wriggler
24. The number of stages in the life history of a fly or mosquito is
    2 4 3 5 6
25. The larva of a mosquito is called
    worm maggott caterpillar adult wriggler
26. Mosquitoes lay their eggs on
    grass mud stagnant water garbage manure
27. The best way to get rid of flies is by
    fly-traps destroying breeding places fly-paper
    fly poison swatting them
28. The best way of getting rid of mosquitoes is by
    citronella mosquito traps poison swatting them
    pouring oil on breeding place
29. The work of the white corpuscles in the blood is to
    carry oxygen carry carbon dioxide digest food
    destroy disease organisms assimilate food
30. Disease bacteria in the human body give off a poison called
    antitoxin toxin insulin lymph enzymes
31. The agent used in the treatment of diphtheria is
    vaccine toxin insulin antitoxin tuberculin
32. A person who does not contract a disease when exposed to the disease germs is said to be
    vaccinated inoculated immune contaminated
    insulated
33. The process of introducing antitoxins into the blood of people is called
    vaccination metabolism assimilation transpiration
    germination
34. Bacteria are
    animals plants insects larva worms
35. The tubes that carry impure blood to the heart are called
    arteries capillaries aorta veins ventricles

36. The continuance from generation to generation of similar traits in living things is called
variation evolution heredity pollination fertilization
37. One celled animals are called
bacteria protozoa molds embryos vacuoles
38. The study of all living things is called
embryology biology bacteriology chemistry geology
39. The esophagus (gullet) is part of the
circulatory system digestive system nervous system reproduction system
40. Plants that are hosts for bacteria which take free nitrogen from the air are called
cotyledons parasites legumes cereals larvae

UNIT—ENERGY, WORK AND MACHINES

1. The best device to use for raising a heavy piano from the first to the tenth floor of a building is an
inclined plane jack combined fixed and movable pulleys lever screw
2. The point on which a lever rests and moves around is called the
arm fulcrum inertia point resistance momentum
3. The force which resists the moving of the surface of one body over the surface of another is called
inertia momentum friction gravity power
4. The number of classes of levers is
6 5 4 3 2
5. A pair of scissors is a lever of the
1st class 2nd class 3rd class 4th class 5th class
6. Turbines are used in power plants to run
steam engines motors dynamos cranes galvanometers
7. An example of a lever of the second class is the
see-saw wheelbarrow scissors balance human arm

8. 33,000 foot-lbs. of work per minute or 550 foot-lbs. per second equals
   1 kilowatt 1 watt 1 erg 1 horse power
   5 horse power
9. The mechanical advantage of an inclined plane 12 feet long and 3 feet high is
   2 3 4 5 ¼
10. If the length of the effort arm (power arm) of a lever is increased its efficiency will be
    increased decreased unchanged
11. Mud flying from a moving wheel and the separation of cream from milk in a dairy separator are examples of
    radiation potential energy centripetal force
    creating energy centrifugal force
12. A foot-pound is the unit of measurement of
    force gravity work horse power power
13. The capacity for doing work is called
    energy momentum inertia efficiency
    mechanical advantage
14. The tendency of a body at rest to remain at rest or a body in motion to remain in motion is called
    friction energy momentum power inertia
15. Kinetic energy is energy possessed by a body when
    at rest suspended in motion it is elevated
16. A moving train or automobile possesses
    potential energy static no energy kinetic energy
    energy of position
17. How much work does a boy weighing 120 lbs. do in walking up stairs to a height of 10 feet?
    12 foot-lbs. 120 foot-lbs. 1200 foot-lbs. 100 foot-lbs.
    12.5 foot lbs.
18. It is possible for energy to be
    created destroyed magnified weighed
    type of pulley
19. The wheel and axle is a
    modified lever modified inclined plane type of pulley

20. By using one movable pulley a person could lift 200 lbs. with a force of approximately
    50 lbs. 25 lbs. 150 lbs. 100 lbs. 75 lbs.
21. Rowing a boat with oars is making use of a lever of the
    3rd class 2nd class 1st class inclined plane
22. A wedge is an example of a
    lever pulley screw wheel and axle inclined plane
23. People standing in a moving train or street car are thrown forward when the train or car stops. This is due to
    centrifugal force friction inertia mechanics
    centripetal force
24. The horse power is a unit of measurement of
    work rate of work force inertia energy
25. A machine is a device that
    generates power creates energy destroys energy
    aids in overcoming resistance
26. The amount of work a one-horse power engine could do in one minute is
    3300 foot-lbs. 550 foot-lbs. 1000 foot-lbs.
    176 foot-lbs. 2500 foot-lbs.
27. Lifting jacks such as the automobile jack are applications of the
    wedge inclined plane screw pulley
    block and tackle
28. The efficiency of a machine is
    always greater than 100% always less than 100%
    sometimes equals 100% may be either less or greater than 100%
29. Automobiles skid oftentimes when turning a sharp curve. This is due to
    friction velocity inertia momentum
    potential energy
30. The ratio of the resistance overcome by a machine to the force applied is a measure of its
    power energy efficiency mechanical advantage
    velocity

UNIT—HEATING AND LIGHTING

1. Temperature is measured by a
   barometer thermometer hygrometer manometer hydrometer
2. Heating causes most substances to
   expand contract liquify solidify radiate
3. The heat of the sun reaches the earth by
   convection conduction expansion gravitation radiation
4. The boiling point of water on the Fahrenheit thermometer is
   100 degrees 212 degrees 0 degrees 32 degrees 22 degrees
5. The freezing point of water on the Fahrenheit thermometer is
   32 degrees 212 degrees 22 degrees 0 degrees 4 degrees
6. The boiling point of water on the Centigrade thermometer is
   10 degrees 32 degrees 212 degrees 200 degrees 100 degrees
7. The freezing point of water on the Centigrade thermometer is
   10 degrees 32 degrees 212 degrees 0 degrees 100 degrees
8. The transferring of heat by movements of currents is called
   convection conduction radiation contraction induction
9. When a fuel burns, the carbon of the fuel unites with
   hydrogen nitrogen oxygen water carbon dioxide
10. Heat can be transferred from one place to another by
    ----------, ----------, and ----------
11. Heat travels through solid substances mainly by
    convection conduction radiation propogation induction
12. A type of heating plant that heats and ventilates at the same time is the
    steam plant hot water plant hot air furnace gas heater electric stove

13. Heating by electricity is accomplished by means of
insulator high resistance wire transformer
electro magnet good conductor
14. Of the following the best conductor of heat is
glass wood water air iron
15. Heat is a
gas fluid molecular substance form of energy
16. The principle substance in fuels is
carbon oxygen nitrogen sulphur mineral matter
17. In a hot water heating plant the hot water pipe which leads to the radiator is attached to the hot water at the
top middle bottom near the bottom
below the middle
18. A calorie is the amount of heat required to raise 1 gram of water
1 degree C 1 degree F 32 degrees F 100 degrees C
19. The unit of measurement of heat is the
degree calorie gram candle power watt
20. A yellow gas flame is due to the presence in the flame of
gases water vapor carbon dioxide carbon particles
metals
21. Houses with hot air furnaces are heated mainly by
conduction convection radiation induction
friction
22. The only method of which heat can pass through a vacuum is
radiation induction convection conduction
expansion
23. Two substances formed when a candle burns are
water oxygen nitrogen carbon dioxide hydrogen
calcium
24. Two chemicals used in a common form of fire extinquisher are
acid base potash soda lime salt
25. The chief source of natural light is the
moon stars gas sun electricity
26. When reading or studying we should sit
facing the light with light directly back of us
so that light comes over the shoulder

with light shining in our eyes

27. The human eye operates on much the same principle as a
plane mirror flash light camera moving picture machine

28. The best kind of light to match colored goods by is
artificial sunlight electric candle kerosene lamp

29. The incandescent (electric) lamp used for lighting was invented by
Morse Bell Marconi Edison Galileo

30. An object which absorbs all colors will appear
black white red green blue

31. An object which reflects all colors will appear
black white red blue green

32. The color of an object is determined by the color of the light which it
refracts reflects absorbs attracts conducts

33. Sunlight is composed of
one color two colors seven colors twelve colors twenty colors

34. The statement that the wall paper of a room should be light in color is
false true unscientific exaggerated

35. A window pane is a substance that is
opaque translucent transparent absorbent semi-opaque

36. A body that does not allow light to pass through it is
opaque transparent translucent transverse black

37. The image formed by a lens is always
erect enlarged inverted distorted diminished

38. When light passes from one transparent substance to another, as from air to water, the rays will be
reflected refracted colored diminished conducted

39. The blurring of images due to irregularities in the curvature of the eye ball is an eye defect called
nearsightedness farsightedness astigmatism oculism

40. The images of things we see fall on the sensitive part of the eye which is called the
    retina pupil iris lens cornea
41. The unit of measurement of intensity of light is the
    watt kilowatt conlomb ohm candle power
42. Light is a wave motion in
    air ether liquids glass solids
43. Photography depends upon the chemical action begun by light on
    nitrates carbohydrates iodine silver salts oxides
44. A person who is nearsighted needs glasses with
    convex lens concave lens straight lens a plane mirror
45. The part of the human eye that forms images of objects that we see is called
    iris pupil mirror lens cornea
46. An object that permits light to pass through it, but through which objects cannot be seen is
    opaque transparent translucent transverse distorted
47. The best form of artificial lighting to use in rooms is probably
    direct indirect semi-direct
48. The color of light depends upon its
    intensity distance from source velocity wave-length

UNIT—MAGNETISM, ELECTRICITY, AND COMMUNICATION

1. A magnet will attract
    paper copper glass wood iron
2. Like poles of magnets will _____ and unlike poles will _____ each other.
3. The number of poles a magnet has is
    1 2 3 4 5
4. The compass can be used in finding direction because the earth
    rotates on its axis is inclined is a magnet
    is a sphere is unequally heated
5. Static electricity is produced by
    chemical action dynamos motors friction magnets

6. Lightning is a discharge of
   magnetism chemical energy static electricity mechanical energy
7. A dry cell produces electricity from
   chemical action mechanical energy magnetism friction inductance
8. A temporary magnet is made of
   soft steel tool steel soft iron copper iron alloy
9. One of the elements of a dry cell is carbon, the other is
   zinc iron copper aluminum lead
10. When a number of dry cells are so arranged that the carbon is always connected to the zinc they are in
    parallel series multiple series-parallel
11. A simple electro-magnet can be made by winding insulated wire on a core of
    copper steel wood porcelain soft iron
12. Underscore two of the following of which an electromagnet is a part
    telegraph sounder electric iron storage cell door bell compass telephone transmitter
13. The telephone was invented by
    Morse Bell Edison Whitney Marconi Fulton
14. The telegraph instrument was invented by
    Marconi Bell Edison Morse Franklin
15. The vibration of the diaphragm of the telephone receiver is produced by a
    carbon granule switch electro-magnet fuse insulator
16. Of the following the best conductor of electricity is
    water copper iron wood glass
17. The electric vacuum cleaner is operated by
    dynamo motor meter galvanometer voltmeter
18. The electron theory of matter states that an electron is
    negative electricity positive electricity an atom of gas an atom of copper neutral

19. Heating by electricity is accomplished by means of an
insulator high resistance wire transformer
electro-magnet good conductor
20. A device which generates electricity by cutting the lines of force of a magnetic field is the
Storage cell motor dynamo transformer galvanometer
21. A device used for increasing or decreasing the voltage of an alternating current is the
electric meter transformer storage cell voltmeter
commutator
22. The ampere is the unit of measurement of
power resistance pressure current magnetism
23. The cost of electricity consumed in the home is figured at a certain cost for each
ampere volt kilowatt kilowatt-hour ampere-hour
24. Two electrical appliances that depend upon the heating effect of an electric current are
electric bell electric motor incandescent lamp
dynamo telegraph electric meter toaster
25. One of the chemicals in a lead storage battery is
sulfuric acid zinc iron hydrochloric acid
sal ammoniac
26. A device used in an electric circuit to prevent the lights or any other electrical appliances from being burned out by an overload of current is the
switch insulator electric meter fuse push button
27. The incandescent electric lamp was invented by
Bell Franklin Edison Morse Marconi
28. If electricity costs 10 cents per kilowatt hour the cost for using twenty 25 watt lamps for one hour will be
5 cents 1 cent 20 cents 6 cents 10 cents
29. The volt is the unit of measurement of
resistance electric pressure power current heat
30. Electric storage batteries are charged by means of
direct current alternating current
either alternating or direct static

31. The A battery of a radio circuit supplies current to the
plate of the tube grid filament antenna grid leak
32. The three parts of the three element radio tube are the
----------, ----------, and ----------
33. In the three element radio tube, electrons shoot out from the
grid hot filament plate plate and grid
34. A function of a crystal in a radio set is to
detect current amplify current reduce current
change current to radio frequency
35. A current of electricity which pulsates back and forth is called
alternating direct semi-direct pulsating direct tuned
36. Two men who have been inventors in the field of wireless telegraphy and radio are
Marconi Faraday Edison De Forest Bell Ford
37. When the grid of the radio tube is positive the electrons are
repelled attracted not affected larger smaller
38. Electromagnetic waves (radio waves) travel in miles per second
1,250 100,000 186,000 56,000 660,000
39. The voltage of the B battery of a radio circuit is usually
less than A batter greater than A battery
same as A battery ½ the A battery voltage
40. A transformer that steps up the voltage of a current has
more turns on secondary more turns on primary
same number turns on primary and secondary

UNIT—TRAVEL AND TRANSPORTATION

1. The airplane was invented by
Whitney Newton Morse Edison Wright Brothers
2. Our chief source of gasoline is
petroleum coal coke coal tar distillation of wood
3. The fuel used in most locomotives is
coal wood oil gas electricity
4. The lifting force of water which causes objects to float is called
gravity inertia momentum buoyancy efficiency
5. Airships are filled with a gas
lighter than air heavier than air same density as air

6. An airplane is run with a
   steam engine gasoline engine oil engine motor
   gas engine
7. When working in a garage with the automobile engine running the garage should be kept open because of the dangerous
   carbon dioxide nitrogen carbon particles
   carbon monoxide
8. Proper lubrication is necessary in the care of an automobile because of
   friction inertia explosions gas pressure
   condensation
9. The spark plug of an automobile engine is placed in the
   cylinder exhause pipe crank case differential
   magneto
10. The first useful steam engine was invented by
    Edison Fulton Watt Whitney Greene
11. When a submarine is under water it is run by
    steam oil gas storage batteries gasoline
12. A balloon is buoyed up by a force equal to the
    weight of air displaced weight of gas in the bag
    weight of the ballast barometric pressure
    force of air currents
13. An instrument used by aviators to determine their altitude is an
    aneroid barometer mercury barometer thermometer
    galvanometer hygrometer
14. When an automobile goes around a curve one rear wheel moves more rapidly than the other. This is made possible by a special device called the
    carburetor clutch differential induction coil
    cylinders
15. When a submarine is to be submerged
    water is placed in tanks water is forced out of tanks
    ballast is thrown overboard nitrogen is compressed
16. The function of the carburetor of an automobile is
    to explode gas lubrication to regulate mixture of air
    and gas to cool the engine condensation

17. The statement that bodies are buoyed up by a force equal to the weight of a liquid displaced is called the principle of
    Newton Galileo Archimedes Bell Pasteur
18. The explosion occurs in the cylinder of the four cycle gasoline engine immediately following the
    intake stroke compression stroke expansion stroke
    exhaust stroke power stroke
19. Two parts that are essential to a steam engine but absent on a gasoline engine are
    slide valve carburetor piston timer fly wheel
    steam chest
20. Helium gas is more desirable for use in airships because it
    is lightest known gas is lighter than hydrogen
    will not burn or explode is more buoyant than hydrogen
    burns readily
21. The efficiency of the gasoline engine compared with the efficiency of the steam engine is
    less more about same always less
22. The principle of the fly wheel of an engine is to
    cool it stop it to make the engine run smoothly
    increase its efficiency start it
23. The timer of an automobile is a part of the
    cooling system lubrication system clutch and gears
    ignition (electric) system differential
24. To test a lead storage battery of an automobile use a
    hydrometer hygrometer barometer ammeter meter
25. When the carburetor of an automobile is adjusted and working properly the exhaust consists chiefly of
    carbon monoxide and carbon dioxide nitrogen
    carbon dioxide and water vapor carbon dioxide and
    nitrogen carbon monoxide and water vapor
26. Gasoline is used for automobiles instead of kerosene because of the difference in their
    density energy value composition purity
    boiling point

VITA

Elwood D. Heiss was born at Martinsville, York County, Pennsylvania on December 30, 1899. He attended the public schools of Wrightsville, York Haven and Manchester, Pennsylvania and graduated from Manchester High School in 1917. He received an A. B. degree from Lebanon Valley College, Annville, Pennsylvania in 1921 and an M. A. degree from Columbia University in 1925.

His professional experience is as follows: Principal of Public Schools, Dillsburg, Pa., 1921-22; instructor of sciences, Media H. S. Media, Pa., 1922-24; instructor of Physics, Union Hill H. S., Union City, New Jersey, 1924-25; assistant in Natural Science, Teachers College, Columbia University, New York City 1925-26; Professor of Biology and Science Education, Milwaukee State Teachers College, 1926-29; Head of the Department of Science, State Teachers College, East Stroudsburg, Pa., 1929—.

He is co-author of the following works:

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